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DESIGN OF PRESTRESSED CONCRETE BRIDGE GIRDER
USING SELF-COMPACTING CONCRETE FOR CAMBODIAN REHABILITATION

VONG Seng

A dissertation submitted to
Kochi University of Technology
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Infrastructure Systems Department of Engineering
Graduate School of Engineering
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ABSTRACT

For rehabilitation of bridge in Cambodia after civil war, it is necessary to choose a type of structure which is economical, fast to build and durable. The precast prestressed concrete structure has been the choice of technology because the concrete structure needs less maintenance compared with other types of structure, the use of prestressing technology can save materials and the precast system can shorten the construction time even in adverse weather the progress of construction can be assisted. However there are still no original design manuals for pretension prestressed concrete (PC) bridge suitable for Cambodia. Therefore the design of prestressed concrete girder has been done to satisfy the requirements of Cambodian situation for now and for future such as the conditions of transporting and moving the girders for construction with the considerations of traffic load, climate and equipment.

The design method of PC girder for bridge construction in Cambodia is presented. The determination of the most suitable section of precast PC girder was made by the conditions of its self-weight and the total cost of bridge superstructure. Firstly section shape was determined by calculation of typical one and half lane girder bridge for the cases of T-shape and box-shape girders. Span was varied from 10m to 25m and concrete strength was varied as 45MPa, 60MPa and 75MPa and the height of girder was chosen to be the most optimum for each case. From this calculation, T-shape was selected by the condition of material cost. Then the design of 20 meters of span of typical two lanes girder bridges with one intermediate diaphragm were made for the cases of T-shape and T-shape with heavy bottom flange girders to determine the required section. The number of girders was varied from 14 to 8 girders in term of the change of top flange width. The height of girders was varied in 5 cm of step from 75cm to 120 cm. The concrete strength was varied as 40MPa, 60MPa and 80MPa. And bond control case was considered.

It was found that high strength concrete is required. As among high strength concrete types, self-compacting concrete (SCC) which needs no vibration gives most advantage, it is decided to be used in this study. The decision to use SCC because Cambodia does not have the appropriate level of technology for producing high strength concrete, SCC can be used to produce high strength concrete in stable condition and the use of SCC can also improve the construction process and the durability of concrete structures in Cambodia. The study of producing SCC with available materials on the market in Cambodia was made. The first experimental study on producing SCC in Cambodia was conducted in June 2004 at the Institute of Technology of Cambodia. The Japanese SCC-designing method was applied. Self-compacting performance was determined by method of slump flow test, V-funnel test and Box-shaped container test. Special requirements to produce SCC are powder and supper plasticizer (SP). The materials for making SCC were investigated. The selection of materials was made by the considerations of economic and environment conditions. Limestone powder was selected to be used. SP which is suitable for making SCC was imported and provided for the experiment by Sika (Cambodia) company. Other materials decided to be used in the experiment were ordinary Portland cement, river sand and crushed rhyolite. The result of trial mixes indicates that it is possible to make SCC in Cambodia. But some difficulties were found such as the slump flow value decreased significantly in short time, the shape of coarse aggregate were not well-rounded.

To apply SCC to PC structures successfully, creep and shrinkage are necessary to be investigated because SCC needs high powder content to produce high segregation resistance. Usually powder beside cement named additive is used to improve the quality of concrete and to reduce the concrete cost. However the existing prediction models for creep and shrinkage such as JSCE2002, ACI209 and CEB-FIP90 do not consider the effect of additive. So the experiment on creep and shrinkage of SCC with different limestone powder contents incorporating with ordinary Portland cement was carried out. The mix proportions were prepared as follows: firstly the mix was designed for the conventional concrete for strength of 55MPa. Based on this mix proportion SCC was designed by increasing the powder content in term of reducing coarse aggregate content and using the superplasticizer. Three types of SCC were produced with the same powder volume but different contents of limestone powder. From the result of the experiment, the shrinkages showed almost the same value for these four types of concrete with the same absolute water content. This means that powder content does not significantly affect on shrinkage. And creep test results showed that SCC which used highest limestone powder content showed highest creep. SCC with higher limestone powder content showed higher creep and SCC which was made by adding limestone powder content to conventional concrete showed higher creep than the conventional even the strength was considerably increased.

The experiment on the long term prestressed loss in the real scale PC girder under real climate in Cambodia was conducted to clarify the production quality of the PC girder using SCC. Prestress loss in PC girder was found lower than the loss calculated by time step method with using the existing creep and shrinkage models. The time dependent camber up to 56 days after transfer was also found lower than the predicted value.

TABLE OF CONTENTS

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Finally, my special thanks go to my father and my two older brothers.

CHAPTER 1: INTRODUCTION

1.1 General

The modernized road network development was started in Cambodia before 1960s. However, all most all of infrastructures including road network had been damaged by the civil war that suffered the country about 20 years from 1970 to until end of 1980s. After finished the civil war, rehabilitation and redevelopment of the infrastructures have been aggressively carried out by the new government.

The rehabilitation and maintenance of the road networks is now most critical and urgent requirement for the country. The large numbers of bridges along the national roads do not cope with the existing traffic loads as they were design to cater lower loads than the prevailing one. There are many cases of bridge collapse due to overloading. In addition, there were no enough bridges to provide access to all part of the country throughout a year. As a result, large parts of the country remain isolated during rainy season. According to the investigation made by the Ministry Public Works and Transport, Cambodia, over 20,000 numbers of bridges including in rural areas' shall be rehabilitated and/or reconstructed.

The rehabilitation and redevelopment of bridges are now been executing by the government with the Official Development Assistance so call ODA from the developed countries, such as France, Australia, USA and Japan. However, it can be observed the fundamental problem that those works are still not be done by local engineers and technicians. Because, all most all of rehabilitation and reconstruction bridge works are carried by the contractors coming from donor countries themselves and they apply own design standers and technologies to the works. Although Cambodian design standards have already been set up under the Australian ODA scheme, it is still not suitable for local conditions. For the future development of the country Cambodia, it is extremely important to set up a kind of system that those works shall be carried out by local engineers and technicians themselves. In order to overcome the existing situation of poor and insufficient infrastructure in Cambodia, this research was intended to develop appropriate design and construction technology for bridge rehabilitation and construction for the country of Cambodian. The issue to be discussed in this dissertation is the design of precast bridge girders that will be made using the pretension prestressed concrete (PC) to sustain the traffic load of non-standard truck and overloading on standard factory vehicles. The affects of the climate like hot weather with high relative humidity in the nights and low in the day time will also be considered. In addition, the weight of the PC girder will also be carefully designed in order to safely transport the girders from the factory to the construction sites and erect properly.

Since Cambodia lacks skilled workforce to ensure high quality in construction works, this study was designed to develop such technology which utilizes less numbers of labors. A series of experiment was made to clarify the possibility of producing the good quality of PC bridge girder for Cambodian rehabilitation. Firstly the experiment on producing self compacting concrete (SCC) with available materials in Cambodia was conducted. SCC is innovated by Japanese researchers and Kochi University of Technology where the author made this study is one of the key center of this new technology. Then creep and shrinkage of SCC with different limestone powder contents were investigated. And real scale of selected PC girder using SCC was produced. The investigation of long term prestressed loss under real climate in Cambodia was made.

1.2 Purpose and scope of research

The main objective of this research is to develop a standard on design and construction of PC girders for short span bridge rehabilitation and construction in Cambodia. The research outcome would be validated by the production of real scale pretension PC bridge girder using SCC in Phnom Penh. This study was also aimed at disseminating the research outcome to the major stakeholders of infrastructure development of Cambodia, the Ministry of Public Works and Transport, Cambodia for the deployment of the technology in bridge rehabilitation and construction.

The scope of the study is the PC girder using SCC for short span bridge of 15 m to 25 m, the production of self-compacting concrete using the materials available on the market in Cambodia, creep and shrinkage of SCC and long term prestressed loss in real scale PC girder using SCC under the real climate in Cambodia.

1.3 Research outline

This dissertation is outlined as follows:

The situation of the infrastructure and necessity of the new technology for Cambodian rehabilitation is explained under the background of Chapter 2. The design methods for the PC girder are presented in Chapter 3. The production of SCC using the locally available materials in the Cambodian markets is explained in Chapter 4. Experiment on long term prestressed loss in real scale PC girder using SCC under the real climate in Cambodia is given the Chapter 5. And the conclusions of this work are presented in Chapter 6. The annexes give the more detail of calculation, formulas and explanations.

CHAPTER 2: BACKGROUNDS

2.1- Cambodian situation

General situation, climate and traffic are described in the following paragraphs:

2.1.1- Situations

Cambodia (Fig. 2.1.1.1) is a country situated in the Southeast Asia and surrounded by Laos, Vietnam, Thailand and gulf of Siam. It has a saucer-shaped with gently rolling alluvial plain drained by the Mekong River and shut off by mountain ranges which the Dangrek Mountains formed the frontier with Thailand in the northwest and the Cardamom Mountains and the Elephant Range are in the southwest. About half of the land is tropical forest. There are many rivers to collect the water from high land to the plain. In the rainy season the water from the high land and Mekong River flows into a big reservoir of Tonle Sap Lake.

The road networks in Cambodia were developed before 1960s. The roads are classified in to three types: National roads (1&2 digits), Provincial roads (3 digits) and the rural roads. The national and provincial roads are under the control of Ministry of Public Works and Transport (MPWT). Similarly, Ministry of Rural Development (MRD) is responsible for the operation and maintenance of the rural roads. The national and provincial roads in Cambodia are 4,165 km and 3,554 km respectively. The rural roads are about 31,000 km. The road networks have large number of bridges, about 4,000 along the national roads alone. The general design standards of the bridges were to cater lighter loads than current loads with many bridges are designed at present.

In addition, during 1970’s and 1980’s, many bridges were destroyed by the war and careless of maintenance. After 1991, the traffic volume had grown rapidly to their pre-war levels. And recently a number of bridges were collapsed due to overloaded vehicles (Fig. 2.1.1.2 and Fig. 2.1.1.3).

This shows that Cambodia needs many bridges to be rehabilitated and to be built. About 20,000 bridges are required for primarily estimation.

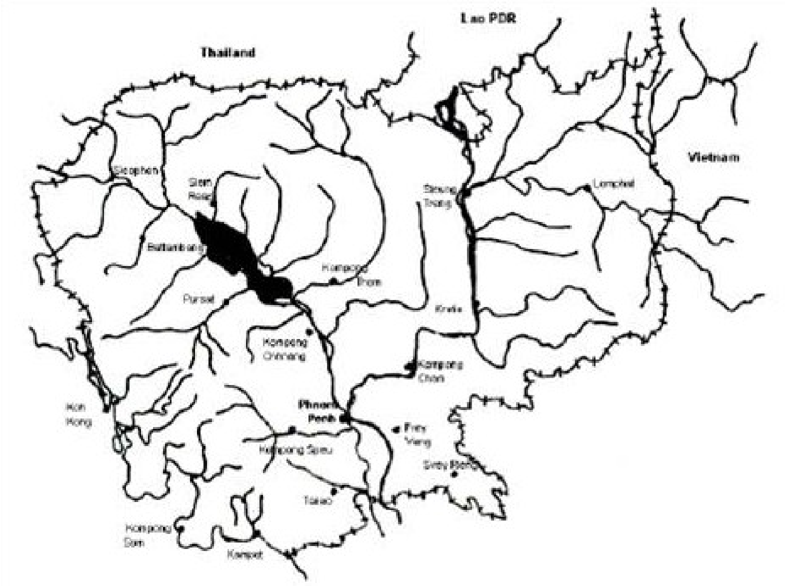


Fig.2.1.1.1 Map of Cambodia

Fig.2.1.1.2 a heavy truck caused the collapse of a bridge on National Road 7 on May 14, 2004

Fig.2.1.1.3 the collapse of a bridge on the road from Siem Reap to Bantey Srey temple on April 10, 2004

2.1.2- Climate

Cambodia has a tropical monsoon climate, with the wet southwest monsoon occurring between November and April and the dry northeast monsoon the remainder of the year. Temperatures in Cambodia are fairly uniform throughout the Tonle Sap Basin area, with only small variations from the average annual mean of around 25°C. The maximum mean is about 28°C; the minimum mean, about 22°C. Maximum temperatures of higher than 32°C, however, are common and, just before the start of the rainy season, they may rise to more than 38°C. Minimum temperatures rarely fall below 10°C.

The relative humidity is high at night throughout the year; usually it exceeds 90 percent. During the daytime in the dry season, humidity averages about 50 percent or slightly lower, but it may remain about 60 percent in the rainy period.

Table 2.1.2 Climate data in Phnom Penh

Sunshine (average hours per day)		Temperatures								Discomfort from heat and humidity	Precipitation and humidity				Wet days more than 2.5 m m/0.1 in	
		Average daily				Highest recorded		Lowest recorded			Relative humidity		Average monthly precipitation			
		minimum		maximum							All hours	x				
		°C	°F	°C	°F	°C	°F	°C	°F		%		mm	in		
Jan	9	21	70	31	87	35	96	14	57	High	71		7	0.3	1	Jan
Feb	9	22	72	32	90	37	98	15	59	High	71		10	0.4	1	Feb
March	9	23	74	34	92	39	102	19	66	Extreme	70		40	1.6	3	March
April	8	24	76	35	94	41	105	20	68	Extreme	73		77	3.0	6	April
May	7	24	76	34	92	38	100	21	69	Extreme	81		134	5.3	14	May
June	6	24	76	33	91	38	101	21	70	Extreme	81		155	6.0	15	June
July	6	24	75	32	89	37	98	20	68	Extreme	83		171	6.7	16	July
Aug	6	26	76	32	89	36	97	22	72	Extreme	83		160	6.3	16	Aug
Sept	5	25	76	31	88	36	96	22	72	Extreme	85		224	8.8	19	Sept
Oct	7	24	76	30	87	34	93	21	70	High	83		257	10.1	17	Oct
Nov	8	23	74	30	86	34	93	18	64	High	79		127	5.0	9	Nov
Dec	9	22	71	30	86	35	96	14	58	High	74		45	1.8	4	Dec

Source: Research Machines plc 2003.

2.1.3- Traffic

In Cambodia the growth rate of transport vehicles has been noticed increasing rapidly for these last 15 years after the year of peace agreement 1991. Non standard vehicles and overloading on standards factory vehicles are observed circulating on the roads. These vehicles caused the serious degradation on the surface of rehabilitated roads and caused the collapse of many bridges before their designed service life. The damage of roads and bridges were also caused by the improperly use and carelessness of maintenance. The overloaded truck is the first factor of road and bridge destruction [14].

Ministry of Public Works and Transport (MPWT), Cambodia decided, in strong action plan, to prevent the risk dedicated from this overloaded truck and making some prevention measures by establishing a Sub-decree on Maximum Weight of Transport Vehicles Circulating on National Roads in September 1999. In the Sub-decree, the road networks in Cambodia were separated into two types: Type A and Type B.

After the traffic law is in effect, the overloaded trucks still caused damage on many roads and bridges as shown in the pictures of Fig.2.1.1.2, Fig.2.1.1.3 and Fig.2.1.3.2 due to weakness of controlling system. Table 2.1.3 shows the weights of overload trucks to the limitation on Maximum Weight which had been investigated [14].
A working group of weight scaling was implemented. The activities of weighing heavy trucks are shown in pictures of Fig. 2.1.3.3.
However most roads in Cambodia as can be seen in Fig. 2.1.3.1 carry lower traffic volume compared with the traffic in the industrial area of developed countries. This

special specific traffic has become a mayor problem to be discussed between road and bridge users, construction engineer and design engineer. Therefore, the traffic model for bridge design has to be well defined to satisfy the safety and economic conditions. The traffic load model for bridge design used in this study is presented in Chapter 3.

Fig.2.1.3.1 the traffic on national road 3

Fig.2.1.3.2 Overloaded truck caused the collapse of a bridge in Mongkul Borei on 07 Sep. 2004

Table 2.1.3 Overloaded Truck and maximum load limit of allowable truck

N	Type of transport vehicles	Permissible gross weight		Overload vehicles (tons) investigated
		Type A (tons)	Type B (tons)	
1	2 Axles truck	16	16	26
2	3 Axles truck	25	20	32
3	4WTrailer/Truck	35	30	44
4	5WTrailer	40	35	61

Fig.2.1.3.3 Activities of truck weight scaling check

2.2- Pretension girder

Nowadays the prestressed concrete technology is commonly being used in a wide range of construction projects all over the world, particularly in bridge structures. But in Cambodia the application of this technology has been just started.

Until now most of bridges in Cambodia were built by conventional reinforced concrete (RC) with multi-short span of about 5 meters of each span as shown in Fig.2.2.1 and steel bridges as shown in Fig.2.2.2. It has been observed that RC bridge took long time for the construction work and a lot of construction materials were used. Steel bridges and timber bridges were easy and took short time for construction but the bridges were damaged after about 5 years due to insufficient maintenance and lack of controlling system. The bridges could only be used for the temporary time. Good quality of steel bridges cost expensive because all construction materials have to be imported (there is no local production of steel) and it requires the good quality of painting for the long term protection against corrosion.

Fig.2.1.3.4: Reinforced concrete bridge

Fig.2.1.3.5: Steel bridge

The experiences in Japan showed that the increased interest in the construction of PC bridges is due to the initial cost and life-cycle cost of PC bridges, including repair and maintenance, are less expensive than those of steel bridges. And compared with the reinforced concrete (RC) bridges, PC bridges have proved to be more economically competitive and aesthetically superior due to the employment of high strength materials (concrete and prestressing tendons). The use of PC technology for bridge construction has been grown rapidly since the first start in 1950s as shown in Fig.2.2.3 [6].

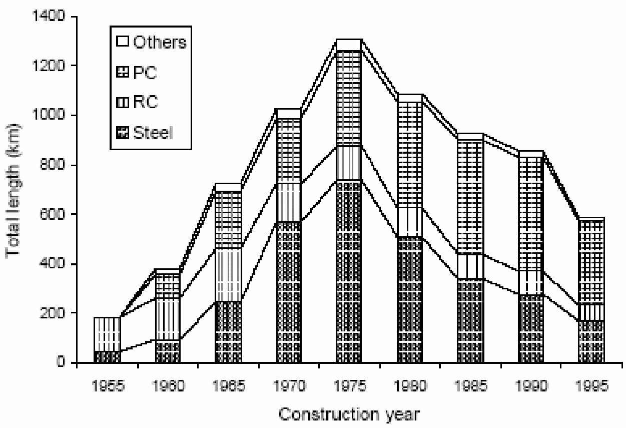


Fig.2.2.1 Trend of construction of different types of bridges in Japan with increasing year

Pre-tensioning and post-tensioning systems have been considered in order to find the appropriate system of design and construction for Cambodian rehabilitation. It is required to set up an appropriate fabrication system of bridge graders that can provide the acceptable quality and quick and stable productions. This study is intended to use of pre-tensioning system because it is possible to produce many girders within a short period of time and under the reliable quality control. A specific method for pre-tensioning concrete is the long-line method. This method, the strands are tensioned for prestressing many members which will be cast end-to-end along a single bed. This economical method saves on labor and wedge costs and allows for reusable forms. As for short span bridge up to 20 meters pre-tensioning PC girder can be designed to satisfy the requirement of Cambodian situation (Chapter 3), pre-tensioning system has been chosen for this study.

Referred to standard girders used in developed countries such as in Japan (Fig.2.2.4), the weight of 20 meters of girder is about 20tons. It is difficult to use in Cambodia because of existing conditions of transportation. The design is needed to satisfy the requirements of Cambodian situation. The design method of PC bridge girder for Cambodian rehabilitation is presented in Chapter 3.

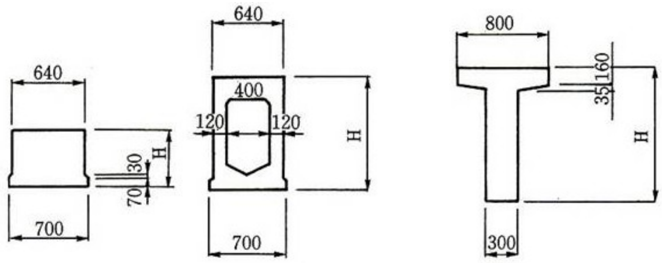


Fig.2.2.4: Standard PC girder used in Japan

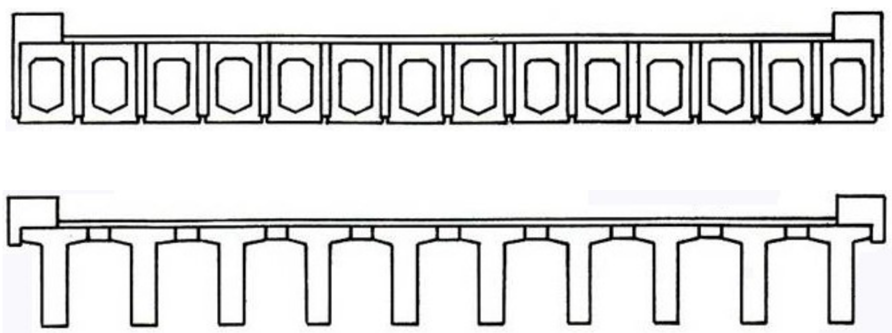


Fig.2.2.5: Typical two lanes bridge in Japan

2.3- Bridge structure systems

Fig.2.3.1 gives an overview of two different typical bridge deck structure systems in common use. In this study, non composite section type is used because it is simple for the construction and design while for composite section type, construction step and interaction between girder and slab have to be considered. In addition, quality of technology and labor affects more on composite section type as it requires more parts to be cast in site than that of the non-composite type. As can be seen in Fig.2.3.1, composite section types mean that the girder is precast at plant and slab is cast in site. And non composite section types means that there is no slab cast in site except the pavement.

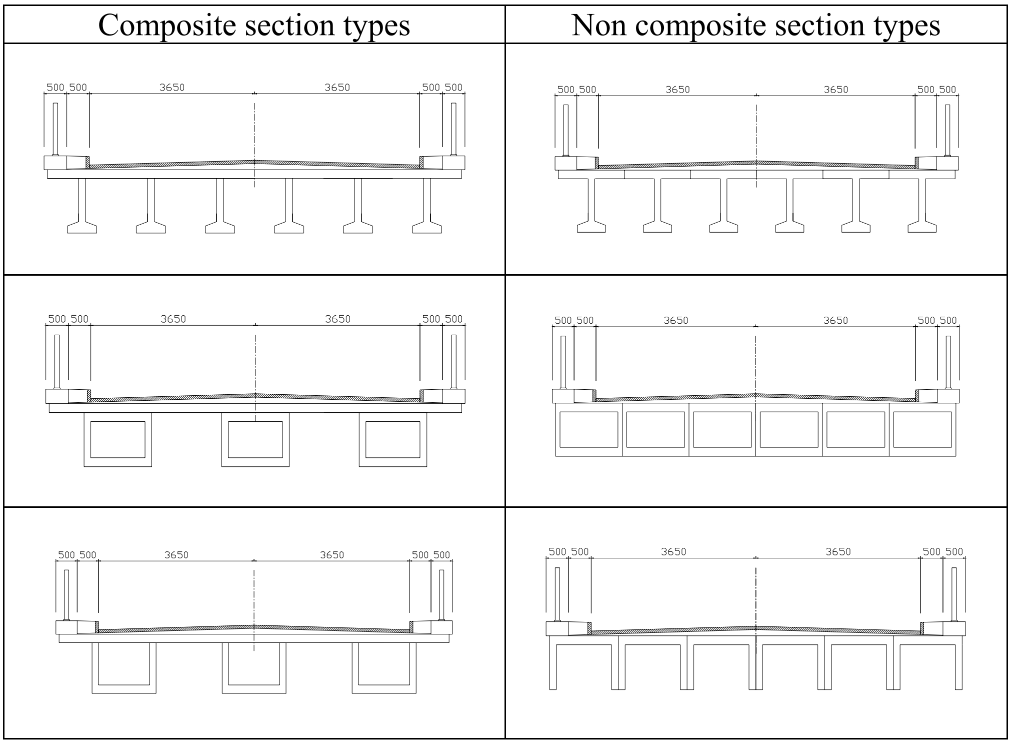


Fig.2.3.1: overview of different typical bridge deck structure systems

2.4- Bridge width

Based on reference [8], three alternative bridge widths as shown in Fig.2.4.1 are commonly used in developing countries. Additional provision can be made for pedestrians and two-wheeled vehicles on one side of the roadway, or on both sides when the bridge is located close to a village. Footways should be a minimum of 1.5m wide. It was decided to be used in this study.

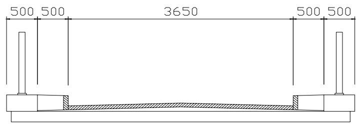
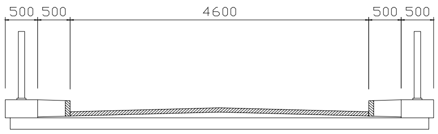
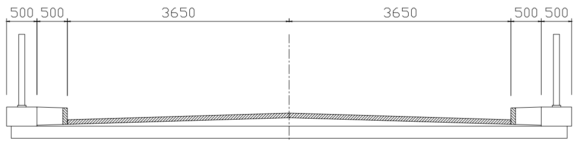
Typical cross sections	Descriptions
	single lane: for traffic flow less than 200 vehicles per day
	one and half lane : two lane for light weight vehicles, one lane for heavy vehicles
	two lanes: appropriate national standard

Fig.2.4.1: typical cross sections

CHAPTER 3: DESIGN METHODS

3.1- Specific design factors for Cambodian situation

The design PC girder for bridge construction in Cambodia should be considered the specific factors which influence the quality production of PC girder. The mains factors to be considered are equipments, local materials for construction, traffic load and climate effect. Equipment for construction in Cambodia is still limited. Investigation of local materials is presented in Chapter 4. The traffic load and climate effect are presented in the following paragraphs.

3.1.1- Traffic load

Unlike roads, bridges are not designed to sustain a total number of standard axle load cycles. Bridges are designed to sustain the traffic load model of heavy vehicles. Most countries have some form of design loading standards for bridges, but Cambodia has not yet determined an appropriate standard even for short span bridges.

The bridges in Cambodia normally carry low traffic volumes but overload weights as described in Chapter 2. The traffic load model is needed for the heaviest predicted loads expected during the life of the structure even it does not need to be designed for the heavy goods vehicles that are common in industrial areas of developed countries.

In general case, the decision of engineer to adopt the traffic load model for bridge design will be influenced by traffic predictions and by the resources available at present and in the foreseeable future. And the engineer should estimate the composition and volume of the vehicular traffic likely to use the road throughout the design life of the bridge. The volume of current traffic can be determined from a simple traffic count. The growth rate over the design life of the bridge is difficult to estimate, but the engineer should attempt to do so, taking into account the local factors which influence traffic growth, such as agricultural or industrial development, and national factors such as development planning and the general increase in gross domestic product. Vehicle weights can vary according to the season. Unless good quality data on vehicle weights are available it is advisable to carry out an axle weighing exercise at the time of year when the heaviest loads are transported.

Where it is expected that future development will increase the desired capacity, the choice is between building a low-cost bridge to serve until the development occurs or building a structure that is wider, longer or stronger than initially required but which will cope with future needs. An alternative solution is to build permanent abutments and a light deck that can be upgraded or replaced when the development occurs.

Regarding the Japanese traffic load model for bridge design, two load types is defined: load type A and load type B. Normally the bridge designed to carry load type A is able to carry 70% of load type B. Tandem load is represented in Fig.3.1.1.1. It is used for local verification, slab design and structural member design of very short span bridge (normally less than 7 m of span). Lane load shown in Fig.3.1.1.2 is used for structural member design and verification.

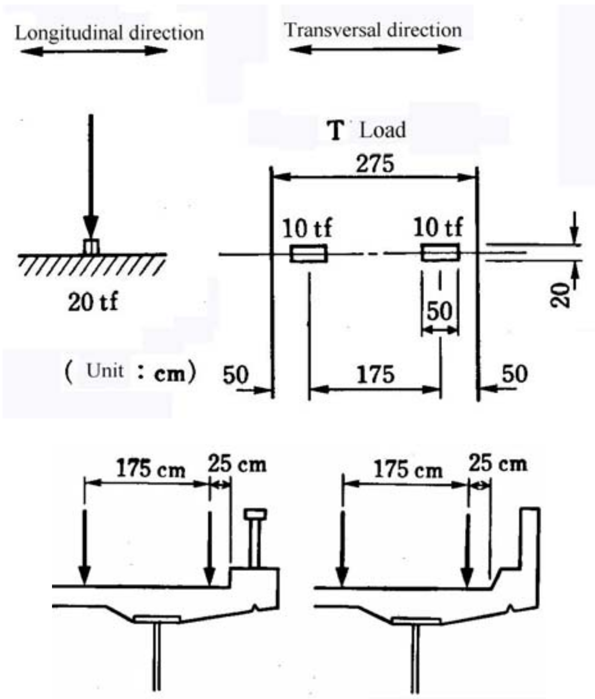


Fig.3.1.1.1: T load

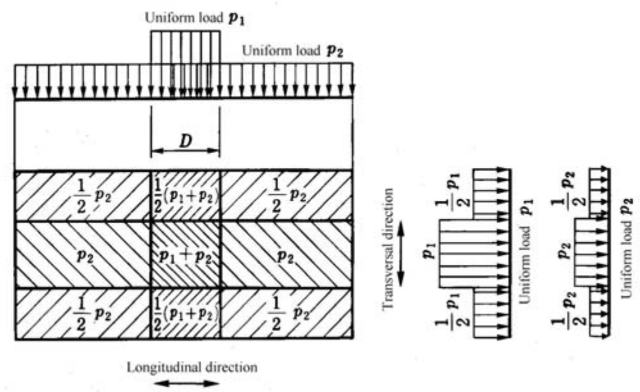


Fig.3.1.1.2: L load

The detail of values p1 and p2 are given in Annex 2. Safety load coefficient of traffic load is 2.5 for the ultimate limit states design. The impact coefficient is $i = \dfrac{20}{50 + L}$ which L is the length of span.

Graphic in Fig.3.1.1.3 shows the comparison between various codes of traffic load model for the case of the bending moment.

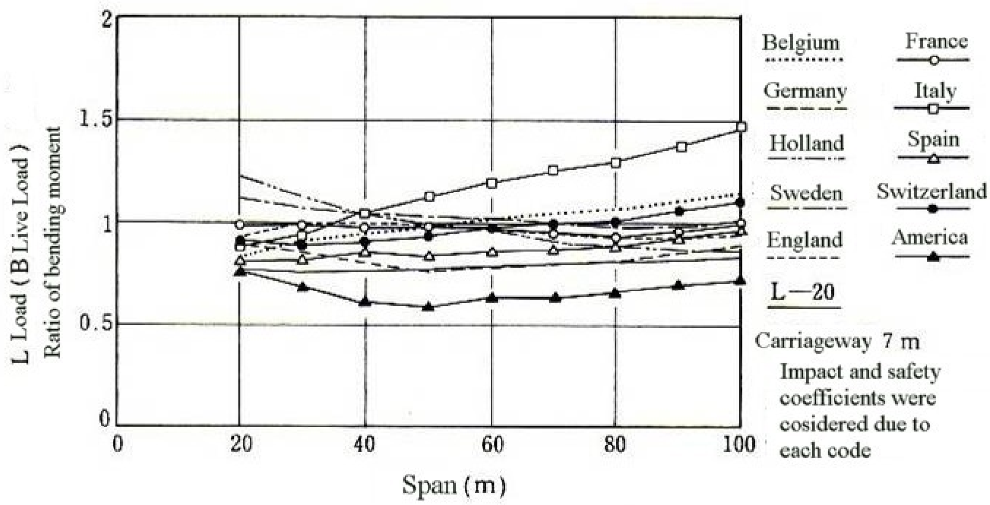


Fig.3.1.1.3: Comparison of bending moment between various codes

This traffic load model is decided to be used for this study based on economic and safety considerations.

3.1.2- Climate effect

By the current climate in Cambodia described in Chapter 2, variation of temperature is neglected. The effect of temperature is taken at 28°C and the effect relative humidity is taken at 70%. As CEB-FIP 90 code model has taken accounts the effect of temperature and relative humidity on shrinkage and creep of concrete, it is used for the consideration of climate effect. The formulations are given below. All the symbols are kept the same as in the original [3], but the forms are rearranged in order to simplify the explanation.

Shrinkage formulation:

$$\frac{\varepsilon_{cs}(t, t_s, T)}{\varepsilon_s(f_{cm})} = -1.55.\left\{1 - \left(\frac{RH}{RH_0}\right)^3\right\}.\beta_{sT}.\left(\frac{(t - t_s)/t_1}{\alpha_{sT}(T) + (t - t_s)/t_1}\right)^{0.5} \quad (1)$$

Creep formulation:

$$\frac{\phi(t,t_0,T)-\Delta\phi_{T,trans}}{\beta(f_{cm}).\beta(t_0)}=\left(\phi_T+(\phi_{RH}-1)\phi_T^{1.2}\right)\left[\frac{\left(t-t_0\right)/t_1}{\beta_H\beta_T+(t-t_0)/t_1}\right]^{0.3} \qquad (2)$$

The equation (1) is represented by the graphics in Fig.3.1.2.1 and equation (2) is represented by the graphics in Fig.3.1.2.2 for the cases of T=20^{o}C, RH=80% and T=28^{o}C, RH=70% with using the same values of h=165mm, ts=1day, t0=4days. The comparison of shrinkage and creep coefficient of concrete due to these two different conditions is given in table 3.1.2.

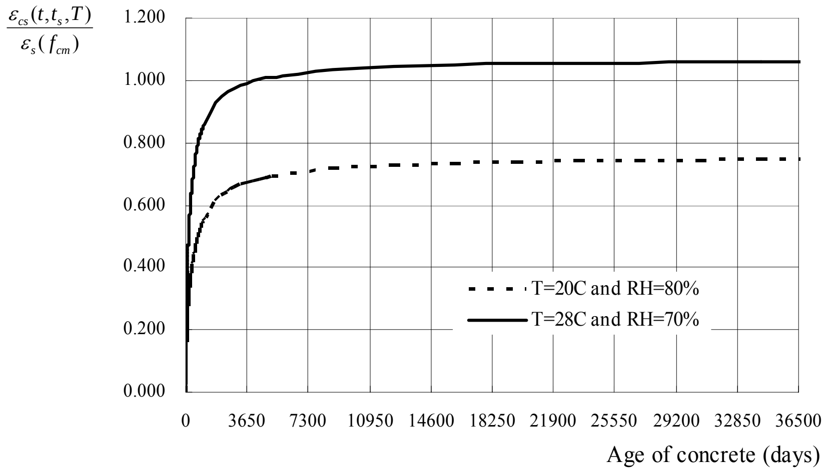


Fig.3.1.2.1: strength independent shrinkage and creep coefficient

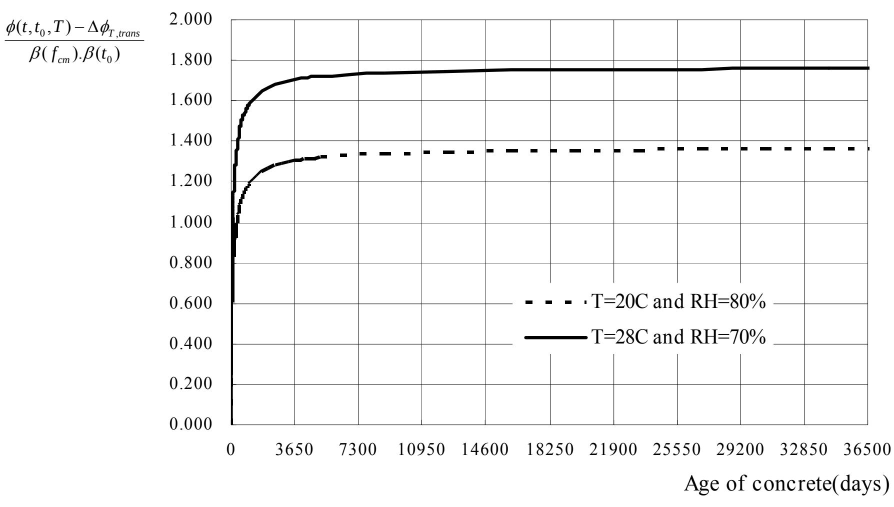


Fig.3.1.2.2: strength independent shrinkage and creep coefficient

Table 3.1.2: Comparison of shrinkage and creep coefficient due to deferent environment conditions

Comparisons	notional size h (mm)					
	100		300		600	
	30days	100years	30days	100years	30days	100years
$\frac{\varepsilon_{cs}(t,t_s=1day, T=28^{\circ}C, RH=70\%)}{\varepsilon_{cs}(t,t_s=1day, T=20^{\circ}C, RH=80\%)}$	1.754	1.414	1.789	1.433	1.793	1.486
$\frac{\phi(t,t_0=4days, T=28^{\circ}C, RH=70\%)-(\Delta\phi_{T,trans}=0.0256)}{\phi(t,t_0=4days, T=20^{\circ}C, RH=80\%)}$	1.421	1.312	1.414	1.271	1.408	1.250

As can be seen in table 3.1.2, shrinkage and creep of concrete under climate in Cambodia show much higher than under climate in European countries. In calculation of prestress loss due to creep and shrinkage of concrete, for example, lump sum predicting long term loss for h = 100mm under climate in Europe is 7% due to shrinkage and 10% due to creep, it means that long term loss under climate in Cambodia will be 7x1.41=10% due to shrinkage and 10x1.34=13% due to creep. So climate effect is an important factor to be considered in prestressed concrete structure design for Cambodia.

3.2- Design of pretension bridge girder

The weight of precast girder is limited at 12 tons for the present time due to the conditions of transportation and moving the girder for construction. Low weight of precast girder can be determined by the combination of the following considerations:

- Shape of section
- High strength of concrete
- High prestressing force
- Number of girders
- Debonded materials: the prestressing force can be applied at largest eccentricity.

To determine the shape of girder, the calculation was made for typical one and half lane bridge as shown in Fig.3.2.1. Dimensions of T-shape and box shape girders are chosen as in Fig.3.2.2. The height of girder depends on the length of span. The calculation was done for the span of 10, 15, 20 and 25 meters and for three cases of design concrete strength: 45MPa, 60MPa and 75MPa. The traffic load type A given in Japanese standard for bridge design is used. Creep and shrinkage models given in CEB-FIP90 are used to predict the loss of prestress caused by climate effect. Temperature of 28^{o}C and relative humidity of 70% are considered as the climate condition in Cambodia.

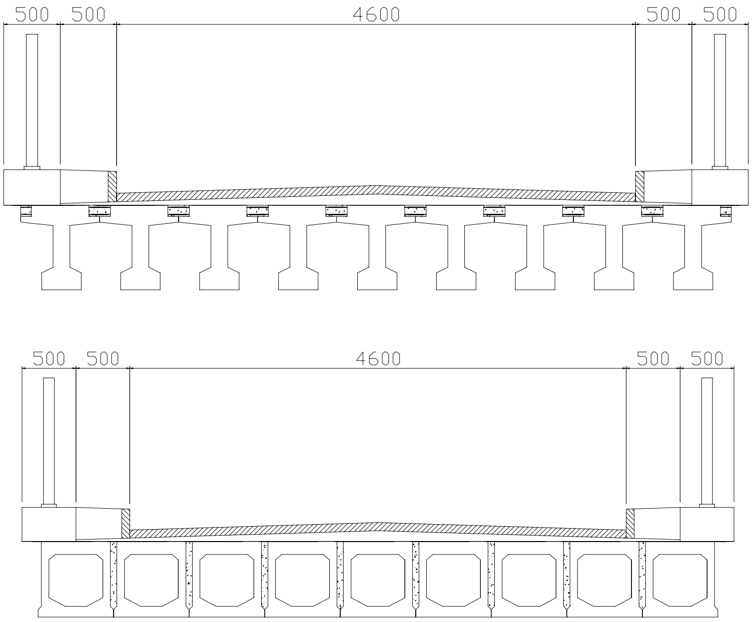


Fig.3.2.1: Typical one lane bridge of T-shape and box shape girders

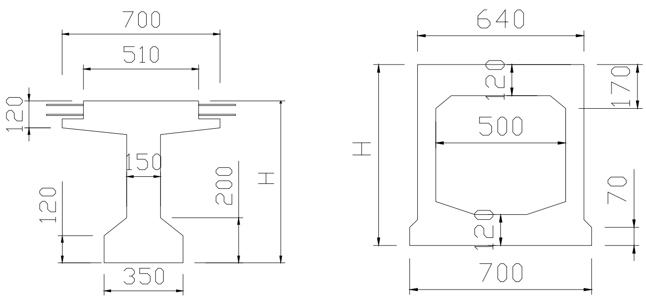


Fig.3.2.2: Dimensions of T-shape and box shape girders

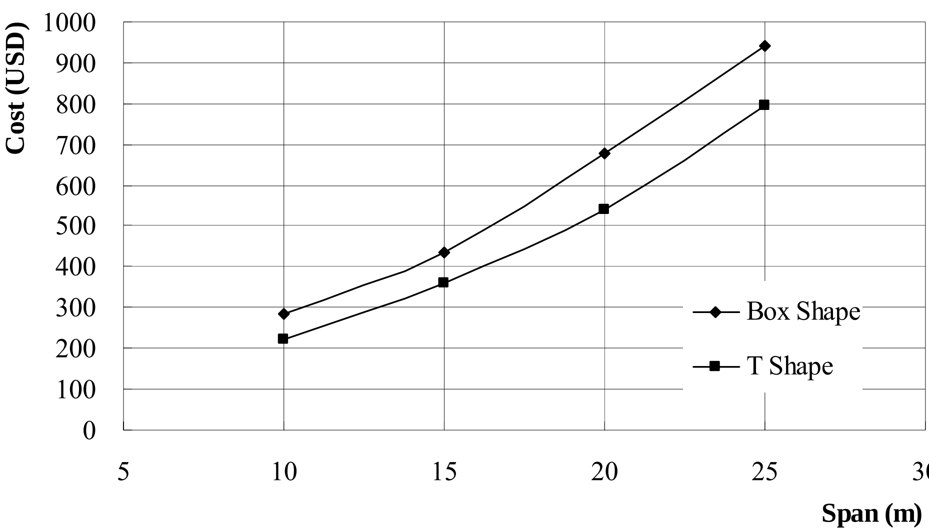


Fig.3.2.3: Material cost of girders for the case of concrete strength 60MPa

Only the cost of concrete and PC strands is taken into account for the material cost shown in the graphic of Fig.3.2.3. And it can be seen that T-shape girder needs less materials compared with box shape. The same results are obtained for cases of design concrete strength of 45MPa and 75MPa. So T-shape girder is selected.

Then typical two lanes girder bridges of T-shape and T-shape with heavy bottom flange of 20 meters of span with one intermediate diaphragm as shown in Fig.3.2.4 and Fig.3.2.5 were designed by:

- Vary the number of girders from 14 to 8 girders in term of the change of top flange width
- Vary the height of girders in 5 cm of step from 75cm to 120 cm
- Vary the design strength of concrete: 40MPa, 60MPa and 80MPa
- Consider with the case of bond control.

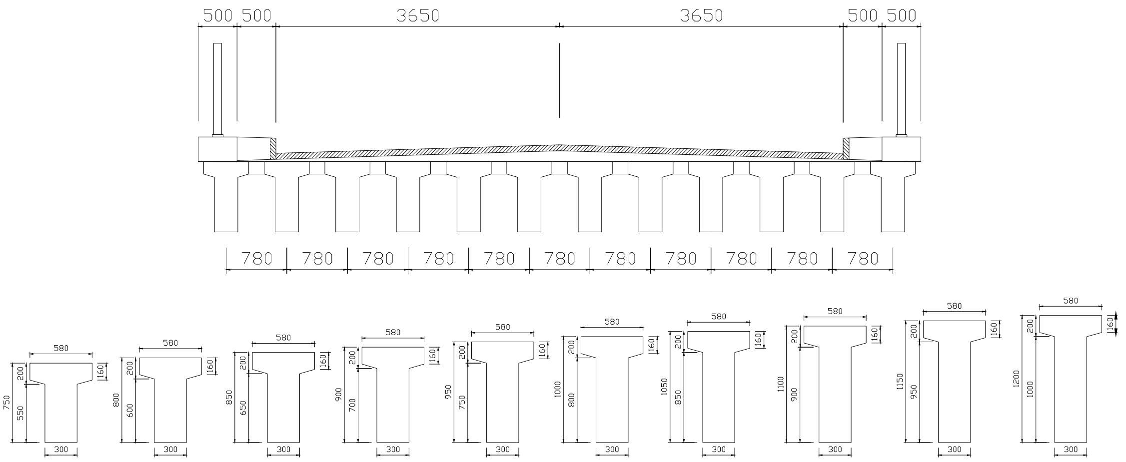


Fig.3.2.4: Typical two lanes girder bridge of T-shape

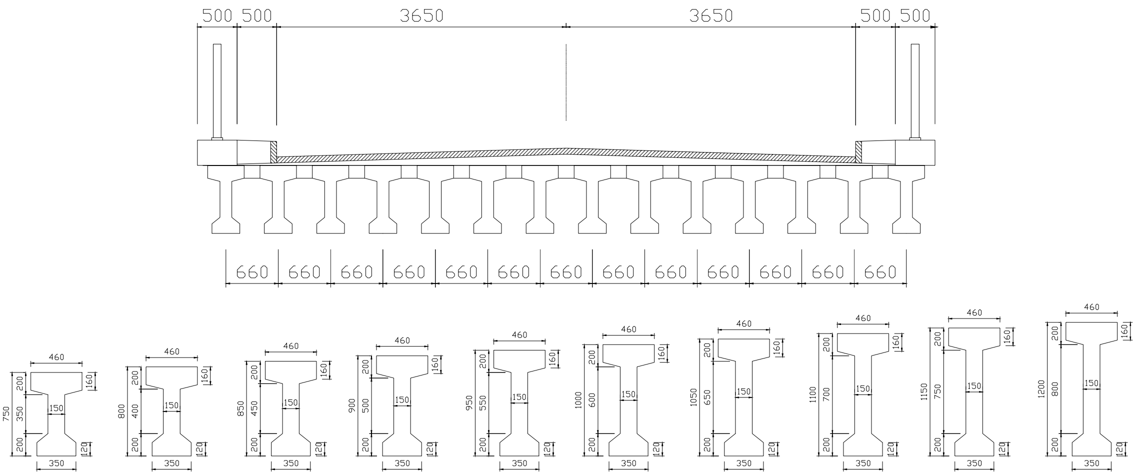


Fig.3.2.5a: Typical two lanes girder bridge of T-shape with heavy bottom flange (14 girders)

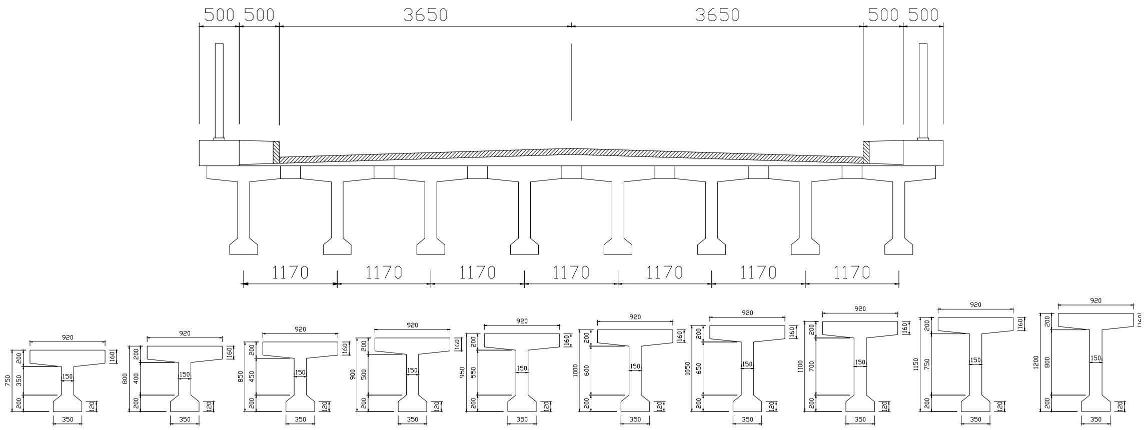


Fig.3.2.5b: Typical two lanes girder bridge of T-shape with heavy bottom flange (8 girders)

The traffic load type B given in Japanese standard for bridge design is used. The calculation was verified at precast, at service and at ultimate limit states. The PC strands used for calculation are 15.24mm of nominal diameter, 1860MPa of ultimate strength and low relaxation.

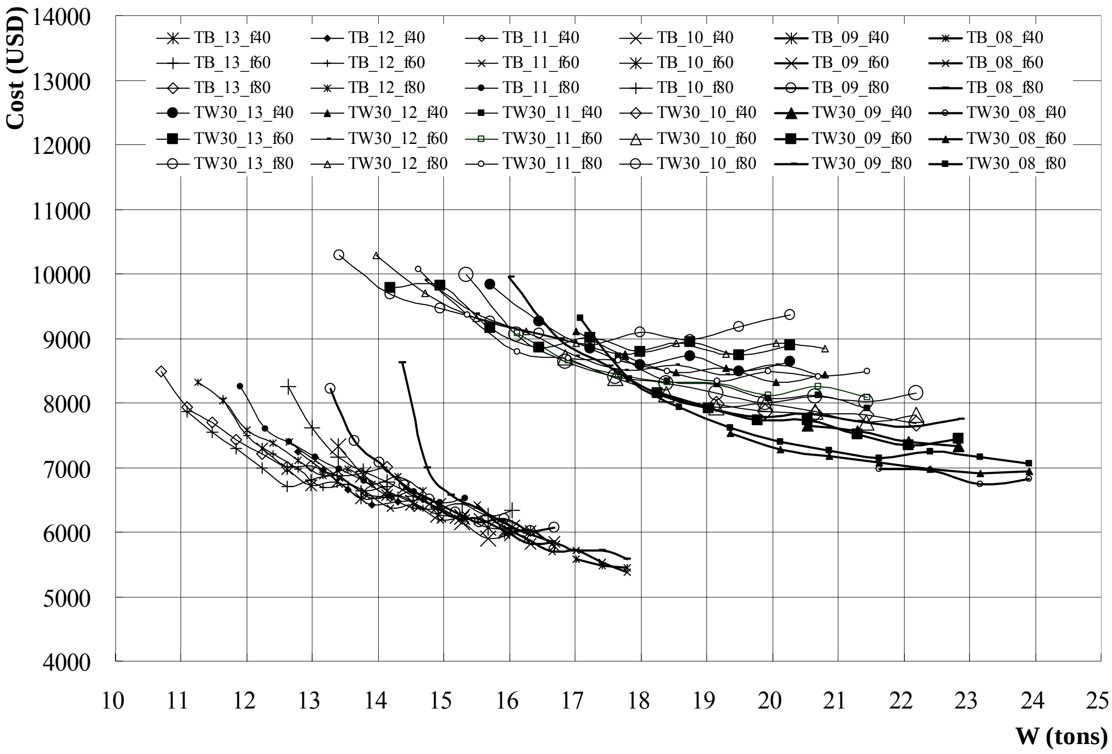


Fig.3.2.6: Material cost of bridge superstructure

The results are represented on the graphic of Fig.3.2.6. Symbol used in graphic: TW30 means T-shape girder with 30cm of web, TB means T-shape with heavy bottom flange girder, the number in the middle part represents the number of girders for the two lanes girder bridge and the final part represents the design strength of concrete. For example: TW30_12_f60 means T-shape girder with 12 girders for two lanes girder bridge and design strength of concrete = 60MPa. Based on this graphic T-shape with heavy bottom flange is selected.

STAAD.Pro was used for structural analysis. Adverse case for bending moment due to traffic load was considered as shown in Fig.3.2.9. Determination of prestressing force and eccentricity is based on the allowable stress method. Magnel diagram is drawn to simplify the calculation as shown in Fig.3.2.10:

(1): border of tensile stress limit of concrete at transfer

(2): border of compressive stress limit of concrete at transfer

(3): border of tensile stress limit of concrete at service

(4): border of compressive stress limit of concrete at service

(5): maximum eccentricity can be applied

Feasible zone: safe combinations of eccentricity e and 1/Pi (Pi is prestressing force at transfer).

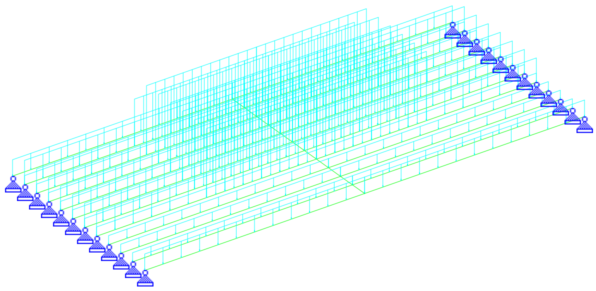


Fig.3.2.9: Traffic load position

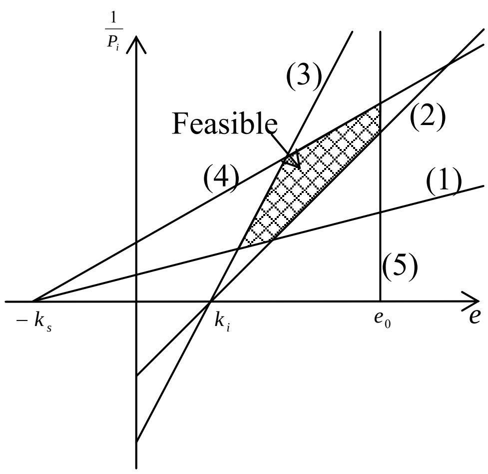


Fig.3.2.10: Magnel diagram

3.3- Determination of girder section

The total cost of bridge superstructure is calculated for each case. The selection of girder was made by the conditions of transportation and economic. With the limitation of its self-weight, the precast PC girder can be selected by using the graphic shown in Fig.3.3.1.

For the case of the limitation of the self-weight at 12 tons, the girder of TB_12_f60 with 85 cm of height is selected. The dimensions of selected girder are shown in Fig.3.3.2. For the selected girder, the total prestressing force just after transfer is 2000kN and its eccentricity is 402.2mm. Bond control is required.

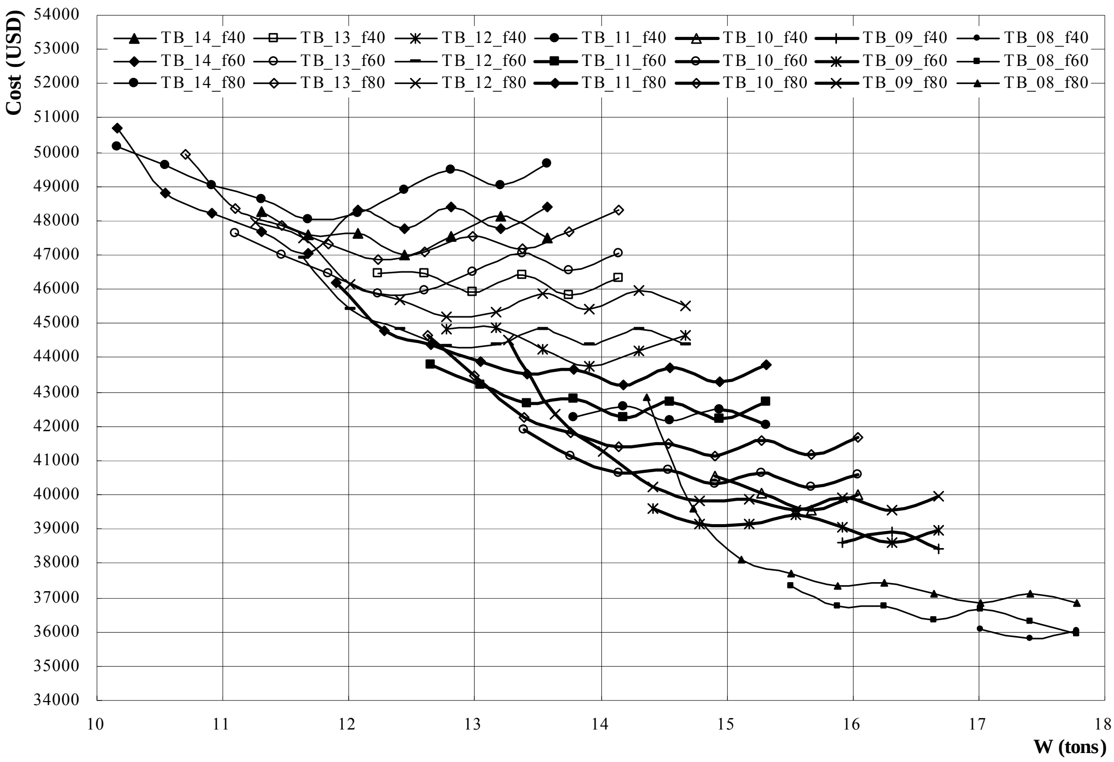


Fig.3.3.1: Total cost of bridge superstructure

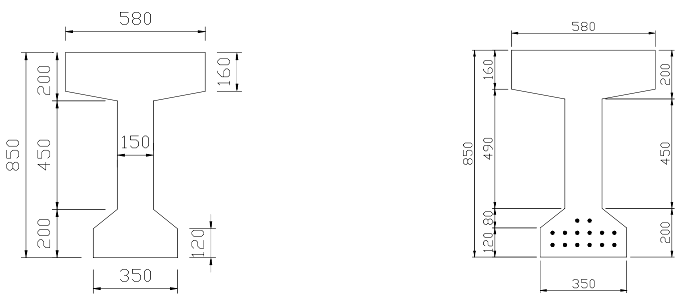


Fig.3.3.2: Selected girders

Based on design method presented above, high strength concrete is required. As SCC gives most advantage among the high strength concrete types, it is suggested to be used. The use of SCC is not only for high strength but also for improving the construction process and the durability of concrete structures in Cambodia. However the use of SCC is still limited because of creep and shrinkage properties has not yet been clarified. So the study of creep and shrinkage of SCC was made which it is presented in the paragraph 3.4. The production of SCC with available materials on the market in Cambodia is presented in Chapter 4.

3.4- Creep and shrinkage of self-compacting concrete

The investigation on creep and shrinkage of SCC is very important for applying SCC to prestressed concrete structures. SCC needs high powder content to produce high segregation resistance. Usually powder beside cement named additive is used to improve the quality of concrete and to reduce the concrete cost. However the existing prediction models for creep and shrinkage such as JSCE2002, ACI209 and CEB-FIP90 do not consider the effect of the additive. Therefore, the experiment on creep and shrinkage of SCC with different limestone powder contents incorporating with ordinary Portland cement was carried out. The mix proportions were prepared as follows: firstly the mix was designed for the conventional concrete for strength of 55MPa. Based on this mix proportion SCC was designed by increasing the powder content and using the superplasticizer. Three types of SCC were produced with the same powder volume but different contents of limestone powder. From the result of the experiment, the effect of limestone powder content on creep and shrinkage was clarified.

Japan and European countries have demonstrated by test and applications the feasibility and benefits of SCC in highway construction. The concrete industry in the United States already recognizes the advantage of SCC [9]. In order to use SCC in prestressed concrete technology successfully, creep and shrinkage are important factors to be investigated. Many types of SCC have been developed among three main types: powder type, viscosity type and combination type.

Usually additive is used to produce SCC for the reason of cost saving and the improvement of concrete quality. Some additives are chemically reactive and some are chemically virtually inert. As powder content and powder type used for SCC are principle parameters effecting on creep and shrinkage, the investigation was made on SCC powder type with different limestone powder contents incorporating with ordinary Portland cement in this experiment. Four mix proportions were prepared as shown in

Fig.3.4.1 and the test was carried out under the same conditions. Furthermore in the prestressed concrete constructions, prestressing force was usually transferred at early age in order to shorten the construction time. In this experiment, the stress was applied at the age of 4 days for creep test.

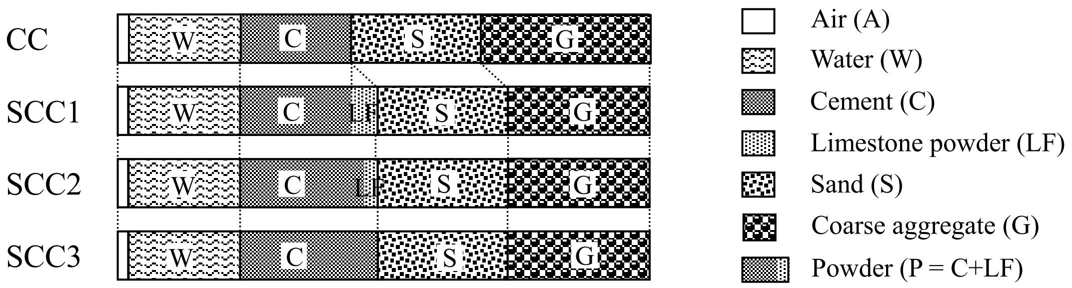


Fig.3.4.1: Four types of mix proportions

Materials used for mix proportions: type of cement was ordinary Portland cement (specific gravity: 3.15), sand was mixed sand of 50% sea sand (specific gravity: 2.59, water absorption: 2.07, F.M.: 2.92) and 50% crushed sand (specific gravity: 2.59, water absorption: 1.67, F.M.: 3.27), coarse aggregate was crushed stone with maximum size of 20mm (specific gravity: 2.69, water absorption: 0.39, F.M.: 6.46), additive was limestone powder (specific gravity: 2.70), and chemical admixture was superplasticizer (type: SP8SB).

Table 3.4.1: Detail of mix proportions and some properties of concrete

Descriptions		CC		SCC1		SCC2		SCC3	
		Mass	Volume	Mass	Volume	Mass	Volume	Mass	Volume
W/C ratio		0.4	1.27	0.4	1.27	0.35	1.10	0.31	0.97
S/(S+G) ratio (%)		44.05	44.98	49.05	50.00	49.05	50.00	49.05	50.00
LF/(C+LF) ratio (%)		0	0	20.58	23.33	10.29	11.56	0	0
Unit mass (kg/m3) Unit volume (m3/m3)	W	175	0.175	175	0.175	175	0.175	175	0.175
	C	437.5	0.138	437.5	0.138	500.85	0.159	567	0.180
	LF	0	0	113.4	0.042	56.7	0.021	0	0
	S	777	0.300	777	0.300	777	0.300	777	0.300
	G	987	0.367	807	0.300	807	0.300	807	0.300
	SP	2.174	-	6.303	-	6.969	-	7.645	-
	A	-	0.02	-	0.045	-	0.045	-	0.045
Fresh properties	flow(mm)	Slump = 10.5 cm		675		625		605	
	V-funnel(s)			10.15		11.45		12.48	
	Box(mm)			325		315		305	
Strength	4days(MPa)	38.19		42.75		52.58		61.70	
	28days(MPa)	56.34		65.36		72.55		80.67	

Self-compactability was evaluated by a slump flow test, a V-funnel test and a Box container test. The strength of concrete was tested at the age of 4 days and at the age of 28 days (specimens: cylinder 100x200mm). The details of mix proportions and some properties of concrete are given in Table 3.4.1. The shape and dimensions of specimen are shown in Fig.3.4.2. A plastic duct for prestressing bar was arranged at the center of specimen. Sixteen point gages for the contact gage meter of 300mm basic length and two wire strain gages were put on two symmetry surfaces.

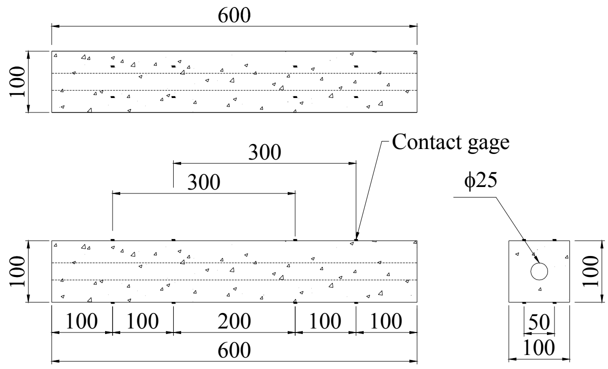


Fig.3.4.2: Dimensions and size of specimen

The experiment was performed under the same test conditions for these four types of concrete as shown in Table 3.4.2. The formwork was removed at 24 hours after casting and all specimens were air-cured in a constant temperature and constant humidity room at 20±2°C, 60±5%.

Table 3.4.2: Test conditions

T	RH	Drying age	Loading age	Loading stress	Curing
°C	%	day	days	%strength at loading age	-
20±2	60±5	1	4	40	Air-cured

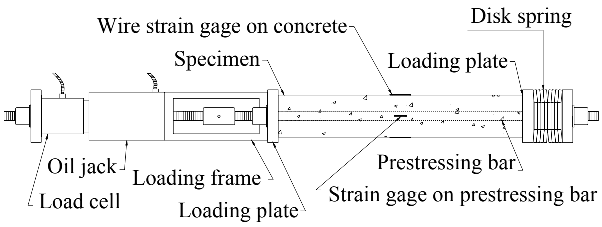


Fig.3.4.3: Testing apparatus

The measurement of shrinkage was started after just removing formwork. For creep test, stress was introduced at the age of 4 days by tensioning a 21mm prestressing bar with apparatus as shown in Fig.3.4.3 [1]. Because of the prestress loss due to shrinkage, creep and relaxation of prestressing steel which occurs with time, each specimen was reloaded to maintain the error of applied stress 2% [10].

The results of shrinkage are shown in Fig.3.4.4 and creep coefficients are shown in Fig.3.4.5.

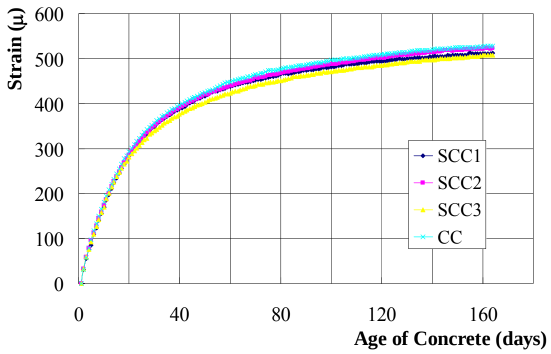


Fig.3.4.4: Test results of shrinkage strains

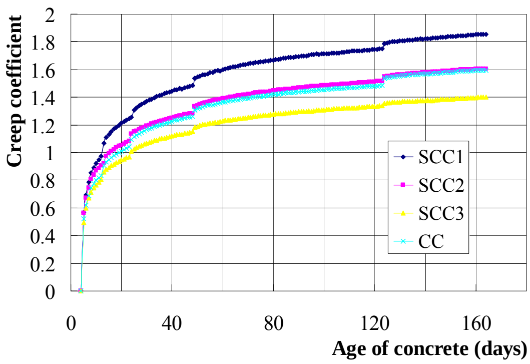
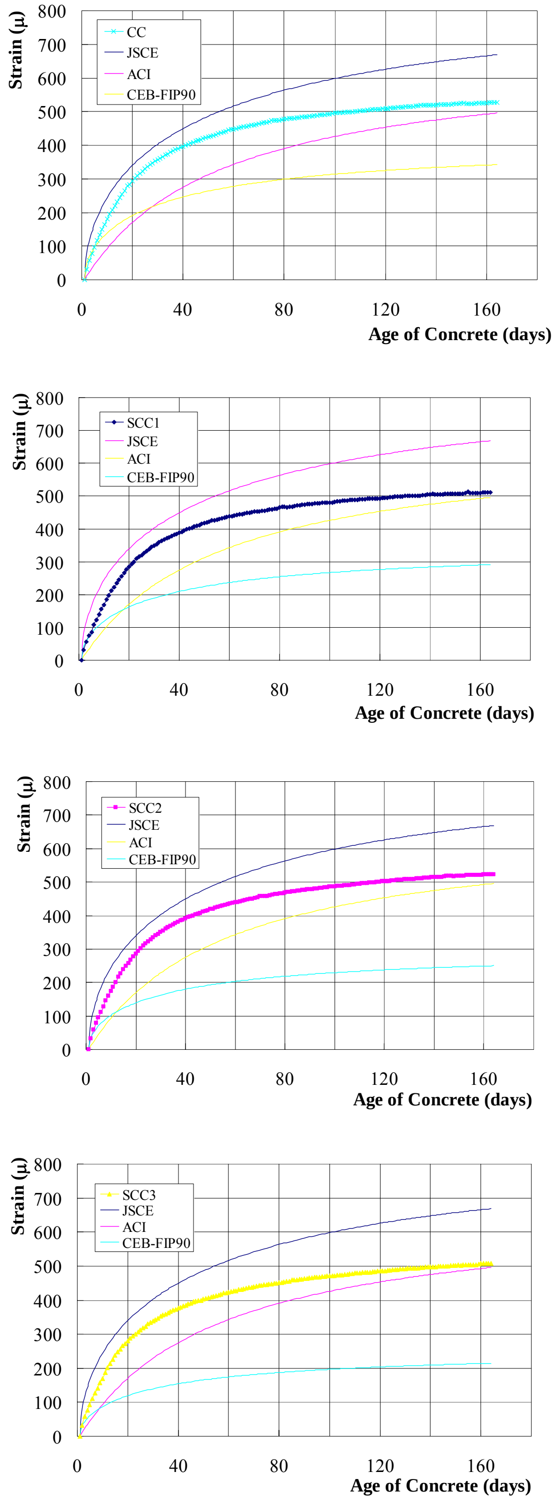


Fig.3.4.5: Test results of creep coefficients

As can be seen, the shrinkages show almost the same value for these four types of concrete with the same absolute water content. This means that powder content does not significantly effect on shrinkage. It was agreed with the reason given in JSCE2002 shrinkage model which uses water content (not W/C) as parameter.

Creep test results show that SCC1 which used highest limestone powder content shows highest creep and creep coefficients are proportional to limestone powder content. On the other hand, SCC1 also shows higher creep than CC. It means that even the case with the same powder volume (SCC1, SCC2 and SCC3) or the case with adding limestone powder content to conventional concrete (SCC1 and CC), the concrete using higher limestone powder content shows higher creep.

Design codes were used to calculate the shrinkage and creep coefficients as shown in Fig.3.4.6 and Fig.3.4.7 in which the graphics show that values obtained from three design codes vary considerably high. It was the reason that shrinkage and creep of CC were investigated in this experiment to compare the results with SCC1 instead of using design codes to study the effect of limestone powder content.



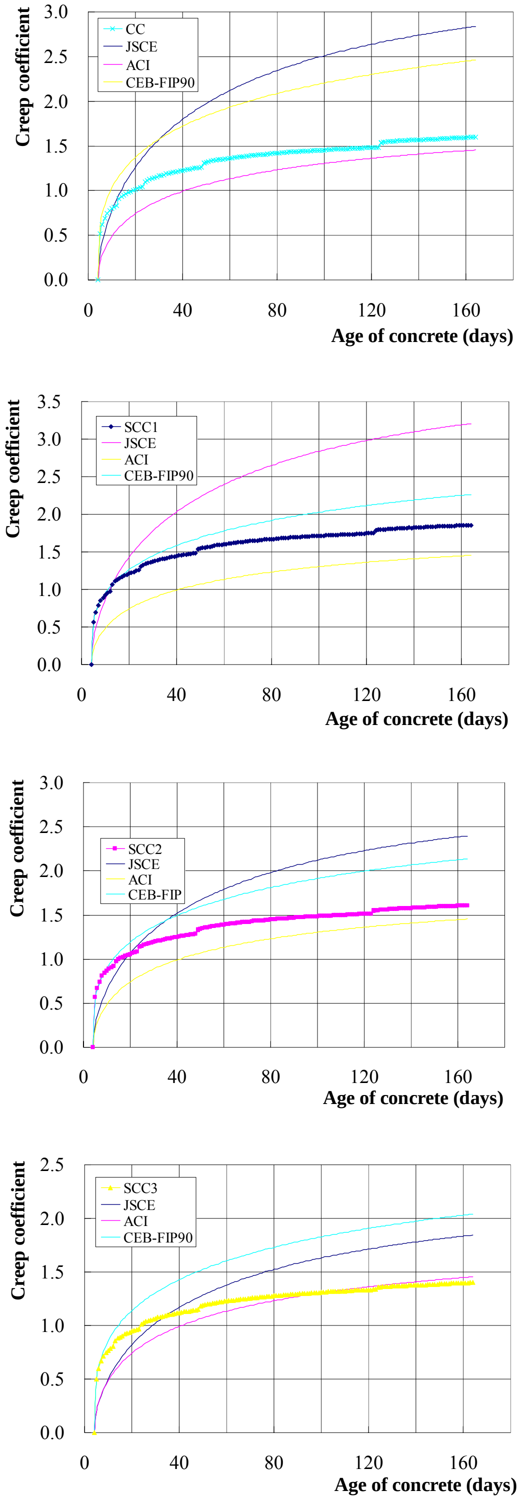


Fig.3.4.6: Shrinkage compared with design codes

Fig.3.4.7: Creep coefficients compared with design codes

3.5- Prestress loss

3.5.1 General

Estimating prestress loss requires an accurate prediction of material properties and of the interaction between creep and shrinkage of concrete and the relaxation of prestressing steel.

Approaches for estimating prestress losses can be divided into the following three major categories:

(a) Time-Step methods

These methods are based on a step-by-step numerical procedure implemented in specialized computer programs for the accurate estimation of long-term prestress losses. As concrete creeps and shrinks, the prestressing strands shorten and decrease in tension. This, in turn, causes the strands to relax less than if they were stretched between two fixed points. Hence, "reduced" rather than "intrinsic" relaxation loss takes place. As the prestressing strand tension is decreased, concrete creeps less, resulting in some recovery. To account for the continuous interactions between creep and shrinkage of concrete and the relaxation of strands with time, time will be divided into intervals; the duration of each time interval can be made progressively larger as the concrete age increases. The stress in the strands at the end of each interval equals the initial conditions at the beginning of that time interval minus the calculated prestress losses during the interval. The stresses and deformations at the beginning of an interval are the same as those at the end of the preceding interval. With this time-step method, the prestress level can be estimated at any critical time of the life of the structure.

(b) Refined methods

In these methods, individual components of prestress loss are calculated separately and the total prestress losses are then calculated by summing up the separate components. Data representing the properties of materials, loading conditions, environmental conditions, and pertinent structural details have been incorporated in the prediction formulas used for computing the individual prestress loss components. Over the years, several methods have been developed.

(c) Lump-Sum methods

Lump-sum methods represent average conditions. They are useful in preliminary design, but the estimated loss should be recalculated in the final design. For example the approximate method given in the current AASHTO-LRFD specification, prestress loss for girders with 270 ksi low-relaxation strands is given by the following formulas:

19+4PPR-4 (ksi) for Box girder

26+4PPR-6 (ksi) for rectangular beams and solid slabs

$33[1-0.15(f'_c-6)/6]+6PPR-6$ (ksi) for I girders

$33[1-0.15(f'_c-6)/6]+6PPR-8$ (ksi) for double Tees and voided slabs

Where: PPR is the partial prestress ration, which normally = 1 for precast pretensioned members.

However when high-strength concrete is used in precast prestressed concrete to allow for high levels of prestress and long span capacities, the experiment on prestress loss is required because the experience on prestress loss in high-strength concrete is still limited at this present time.

In this study, the long term prestress loss was preliminarily supposed at 20% of initial prestressing force just after transfer. Then the verification was made by formulas given in JSCE and by time step method which implemented in a computer program named section (Annex 3).

3.5.2 Calculation of prestress loss

Prestress loss was considered from the tensioning prestressing strands to the end of service design life as shown in Fig.3.5.2.1.

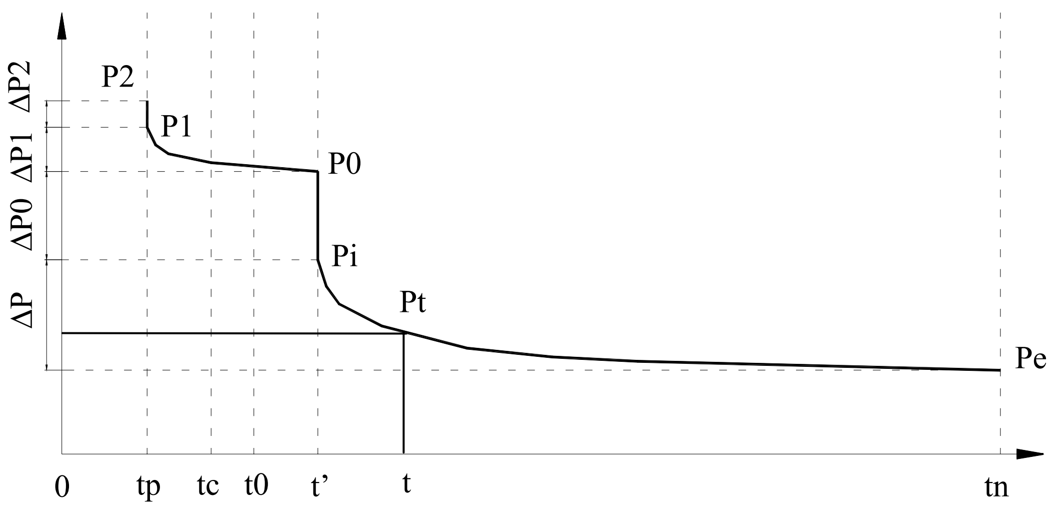


Fig.3.5.2.1: Process of prestress loss in pretension system

tp: time at tensioning the strands

tc: time at casting concrete

t0: time at starting drying concrete
t': time at transfer (cutting strands)
t: time at any time
tn: time of service design life
P2: Prestressing force at tensioning
P1: Prestressing force just after releasing
P0: Effective prestressing force before transferring (cutting strands)
Pi: Initial prestressing force just after transferring (cutting strands)
Pt: Effective prestressing force at any time t
Pe: Effective prestressing force at service design life
ΔP2: Loss at tensioning due to displacement of wedge when locking and the prestressing yard for the case of short and/or flexible prestressing yard
ΔP1: Loss due to relaxation from the time of tensioning to the time of transferring
ΔP0: Instantaneous loss due to shortening
ΔP: Long term loss at service design life
ΔPt: Long term loss at time t

The prestress loss is expressed in general form as shown in equation 3.5.2.1

$$\Delta\sigma_p = E_p \Delta\varepsilon_p + \Delta\sigma_{pr}(t, t_p) \qquad (3.5.2.1)$$

$E_p \Delta\varepsilon_p$: Loss due to shortening

$\Delta\sigma_{pr}(t, t_p)$: Loss due to relaxation from tensioning at time tp to any estimated time t

The loss at transfer and loss term loss at service design life, the formulations given in JSCE as described below were used.

(a) Loss at transfer

$$\Delta\varepsilon_p = \Delta\varepsilon_{cpg} = \frac{\sigma'_{cpg}}{E_c}$$

$$\Delta\sigma_{p0} = n_p \sigma'_{cpg} \qquad (3.5.2.2)$$

Where $n_p = E_p / E_c$

By including the loss due to shrinkage from the drying time to transfer time, loss at transfer can written as

$$\Delta\sigma_{p0} = n_p \sigma'_{cpg} + \varepsilon_{cs}(t', t_0) E_p \qquad (3.5.2.3)$$

(b) Long term loss at service design life

The loss due to creep and shrinkage

$\Delta\varepsilon_p = \Delta\varepsilon_{pcs} = \Delta\varepsilon_{cpgcs}$: At the level of prestressing force center

$$\Delta\varepsilon_{cpgcs} = \varepsilon_c(t, t') - \varepsilon_c(t', t')$$

$$\varepsilon_c(t, t') = \frac{\sigma'_{cpt} + \sigma'_{cdp}}{E^*} + \frac{\Delta\sigma_{cpg}}{E^{**}} + \varepsilon'_{cs}(t, t')$$

$$\varepsilon_c(t', t') = \frac{\sigma'_{cpt} + \sigma'_{cdp}}{E_c}$$

$E^* = \dfrac{E_c}{1+\varphi}$: Effective modulus of concrete

$E^{**} = \dfrac{E_c}{1+\chi\varphi}$: Age adjusted effective modulus of concrete

$$\Delta\varepsilon_{cpgcs} = \frac{\sigma'_{cpt} + \sigma'_{cdp}}{E_c}.\varphi + \frac{\Delta\sigma_{cpg}}{E^{**}} + \varepsilon'_{cs}(t, t')$$

$$\Delta\sigma_{cpg} = -\left(\frac{\Delta P_{cs}}{A_c} + \frac{\Delta P_{cs} e^2}{I_c}\right) = -\frac{\sigma'_{cpt}}{\sigma_{pt}} \Delta\sigma_{pcs}$$

$$\Delta\sigma_{pcs} = \frac{n_p \cdot \varphi(\sigma'_{cpt} + \sigma'_{cdp}) + E_p \cdot \varepsilon'_{cs}}{1 + n_p \cdot \dfrac{\sigma'_{cpt}}{\sigma_{pt}} \cdot (1 + \chi\varphi)}$$

For the case $\chi = \dfrac{1}{2}$

$$\Delta\sigma_{pcs} = \frac{n_p \cdot \varphi(\sigma'_{cpt} + \sigma'_{cdp}) + E_p \cdot \varepsilon'_{cs}}{1 + n_p \cdot \dfrac{\sigma'_{cpt}}{\sigma_{pt}} \cdot \left(1 + \dfrac{\varphi}{2}\right)} : \qquad (3.5.2.4)$$

Where $\Delta\sigma_{pcs}$: loss of stress in the prestressing tendon due to creep and shrinkage of concrete

φ : creep coefficient of concrete

ε'_{cs}: Shrinkage strain of concrete

n_p : Ratio of Young's modulus of prestressing tendon to concrete

σ_{pt} : Tensile stress of prestressing tendon just after prestressing

σ'_{cpt} : Compressive stress of concrete at the location of prestressing tendon by prestressing force just after prestressing

σ'_{cdp} : Compressive stress of concrete at the location of prestressing tendon by permanent load

$\Delta\varepsilon_{cpgcs}$: The change of strain in concrete due to creep and shrinkage at the level of prestressing force.

The loss due to relaxation

$$\Delta\sigma_{pr} = \gamma\sigma_{pt} \quad (3.5.2.5)$$

Where $\Delta\sigma_{pr}$: loss of tensile stress due to relaxation

γ : Apparent relaxation ratio of tendon

$$\gamma = \gamma_0\left(1 - 2\Delta\sigma_{pcs}/\sigma_{pi}\right)$$

Where $\Delta\sigma_{pcs}$: decrease in tensile stress of prestressing bar due to the shrinkage and the creep of concrete

σ_{pi} : Tensile stress of prestressing bar just after prestressing

γ_0 can be determined by using Table 3.5.2.1

γ_{01} and γ_{02} can be determined by using Table 3.5.2.2

Table3.5.2.1: γ_0

Initial tensile stress/tensile strength	γ_0
0.75	γ_{02}
0.70	$\gamma_{01} + 0.64(\gamma_{02} - \gamma_{01})$
0.65	$\gamma_{01} + 0.36(\gamma_{02} - \gamma_{01})$
0.60	$\gamma_{01} + 0.16(\gamma_{02} - \gamma_{01})$
0.55	$\gamma_{01} + 0.04(\gamma_{02} - \gamma_{01})$
0.50	γ_{01}

Table 3.5.2.2: γ_{01} and γ_{02}

Kind of prestressing steel	Specified value for the initial tensile stress divided by tensile strength	
	0.50	0.75
Prestressing wire and wire strand	γ_{01} = 3 %	γ_{02} = 15%
Prestressing bar	γ_{01} = 1%	γ_{02} = 7%
Low-relaxation prestressing steel	γ_{01} = 1%	γ_{02} = 4%

The relaxation ratio of prestressing steel shall be the value three times of that for 1000 hours test obtained by the relaxation test.

The long term loss at any time was calculated by using time step method. Creep and shrinkage models given in JSCE were used. Relation ration is proposed as in equation 3.5.2.6. Elastic recovery due to prestress loss was not considered. When environment temperature is taken into account, creep and shrinkage models given in CEB-FIP were used.

$$\gamma = \gamma_0 (\frac{t}{1000})^{0.16} \qquad (3.5.2.6)$$

Where t: time in hours (considered from tensioning)
γ_0 : The value given in Table 3.5.2.1

The calculation of prestress loss is implemented in a program named “Section” which is presented in Annex 3.

CHAPTER 4: PRODUCTION OF SELF-COMPACTING CONCRETE IN CAMBODIA

4.1- General

As known by its name, Self-Compacting Concrete (SCC) is a type of concrete that can flow under its own weight and completely fill a formwork, even in the presence of dense reinforcements, without vibration causing no segregation. Because it requires no vibration, many advantages of using SCC are provided such as faster construction, less manpower, easier placing, better surface finishes, thinner concrete section, highly effective in reducing noise especially in precast product plants, and safer working environment.

The special rheological requirements of SCC are high deformability with high segregation resistance. The additions of powder are commonly used to improve and maintain the workability, as well as to regulate the cement content and so reduce the heat of hydration, and special concrete admixture are necessary to be able to achieve fluid concrete with controlled workability, very high water reduction, and stable and cohesive concrete.

SCC was developed in Japan starting in the mid 1980s by Professor Hajime Okamura and then, in the summer of 1988 Kazumasa Ozawa was able to create the first SCC. Until now it has been developed and used for almost two decades. In Japan, it has become a standard concrete but in Cambodia it is a new and special concrete.

The durability problem caused by construction work (less skilled labors and less maintenance in the service time) is a main obstacle to be solved in Cambodia and the design for some types of concrete structures has been limited because of the difficulty of compacting concrete. Due to this necessity, the first experimental study on producing SCC in Cambodia was conducted in June 2004 at the Institute of Technology of Cambodia. The Japanese SCC-designing method was applied.

Advance investigation on materials available in Cambodia for producing SCC was made. The materials decided to be used in the experiment were ordinary Portland cement, limestone powder, river sand and crushed rhyolite that these materials are available on the market in Cambodia. Supperplasticizer was provided by Sika(Cambodia) company for the experiment. Self-compacting performance was determined by method of slump flow test, V-funnel test and Box-shaped container test.

The result of trial mixes indicates that it is possible to make SCC in Cambodia. But some difficulties were found such as the slump flow value decreased significantly in short time.

4.2- Material investigation

The materials were selected by the conditions of economic and environment. The cost of some materials available in Cambodia is shown in Table 4.2.1.

Table 4.2.1: cost of materials

Materials	Sand	Coarse aggregate	Portland cement	Limestone powder	Fly ash	Silica fume	Viscocrete HE-10
Unit	ton	m^3	ton	ton	ton	ton	liter
Unit cost (USD)	4.5	12.5	72	26	100	990	3

4.2.1- Cement (C)

In Japan and in Europe, the moderate heat or low heat cement types have been used for SCC because SCC need high content of cement that can cause the temperature rise in concrete. In Cambodia, only Ordinary Portland cement is available at the present time. So it was used in this research. Its chemical composition and physical properties are shown in Table 4.2.2.

Table 4.2.2: Chemical composition and physical properties of cement

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Sp. gravity	Sp. Surface area
%	%	%	%	%	%	%	%		cm^2/g
21.1	5.2	3.3	65.3	1.0	2.71	0.08	0.54	3.15	3358

4.2.2- Additions

First some industrial by-products such as granulated blast furnace slag powder, fly ash, and silica fume were considered. Some of them could be found on the market in Cambodia, but the cost was very high. Then the agricultural by-products such as rice husk ash and rice straw ash was discussed. These raw materials were very suitable for making SCC, but many factors needed to be investigated before using and it required the future research. Finally stone powder such as finely crushed granite, dolomite and limestone was considered. Due to past experience of using limestone powder and because limestone powder can be found in Cambodia, limestone exists in Kompot and Battembang provinces, so limestone powder was selected to be used. A typical application example of limestone powder in Japan is its use in the anchorage of the

Akashi Kaikyo Bridge. Limestone powder can also inhibit the temperature rise of concrete when its proportion in concrete is high.

4.2.3- Aggregates

Normally in Cambodia, the sand (S) used for construction is river sand.

Coarse aggregate (G) is gravel or crushed stone made from:

- Basalt in Kampong Cham and Snoul,
- Granites at Phnom Basset and in Kampong Chhnang,
- Limestone in Sisophon, Battambang and Kompot,
- Rhyolite from several hills near to Phnom Penh,
- …

In this research, crushed rhyolite was used. The particle size distribution of fine and coarse aggregates is given in graphic of Fig.4.2.1. Two grading types of coarse aggregate were used.

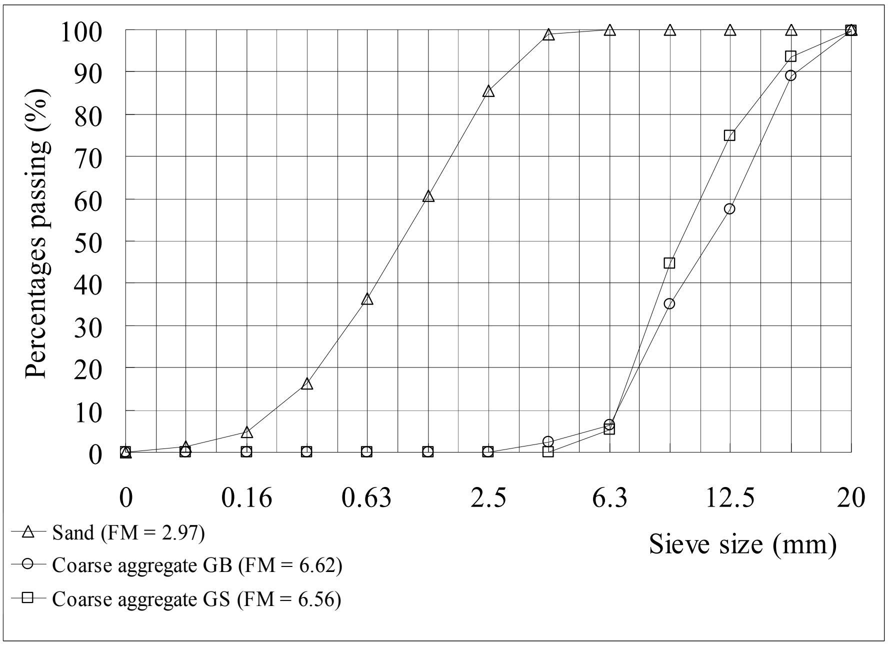


Fig 4.2.1: Sieve analysis of aggregates

Further information on the physical properties of aggregates is given in Table 4.2.3.

Table 4.2.3: Physical properties of aggregates

Type	Specific gravity	Absorption (%)
Sand	2.57	1.38
Crushed stone	2.73	0.42

Because the coarse aggregate were not well graded, more powder content was needed. And because the ordinary cement type was used, this type of SCC would show more plastic shrinkage and creep which require the future investigation for long term of hardened concrete performance.

4.2.4- Superplasticizer (SP)

The high requirements of SCC regarding workability, homogeneity and cohesion result in great demands on SP. The newest developments of SP technology shows outstanding results compared to normal SP. At the time of experiment only SP for conventional concrete is available on the market in Cambodia. The SP suitable for SCC is still not available. Because of its necessary requirement for making SCC, the study was made to find this material. The first consideration was to take this type of SP from Japan to Cambodia. Another consideration is to get this product through the local company of admixture for concrete. Fortunately, SP suitable for SCC could be ordered from Vietnam. General Manager of Sika (Cambodia) Ltd. had ordered Viscocrete HE-10 and offered specially for the experiment. He said that this type of SP will be available in Cambodia when the requirement increases. Viscocrete HE-10 which is ideal for the purpose of powerful plasticizing, special formulations to keep concrete cohesive and homogeneous, and controlled workability was used for the experiment

4.2.5- Apparatus

The apparatus for judging the fresh performance of SCC were made according to the recommendation of Japanese Society of Civil Engineering for self-compacting concrete.

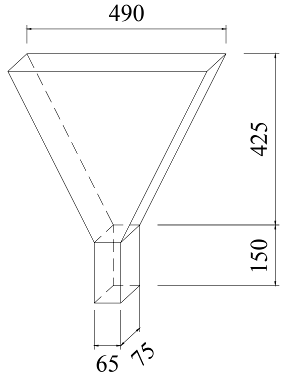


Figure 4.2.2: V-funnel (Unit: mm)

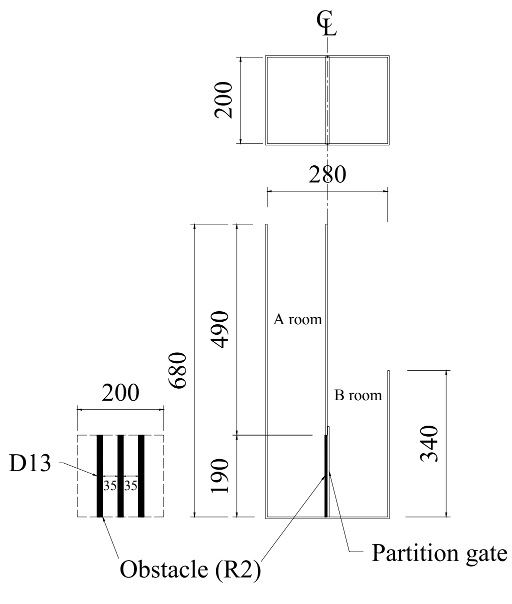


Figure 4.2.3: Box-shaped container (Unit: mm)

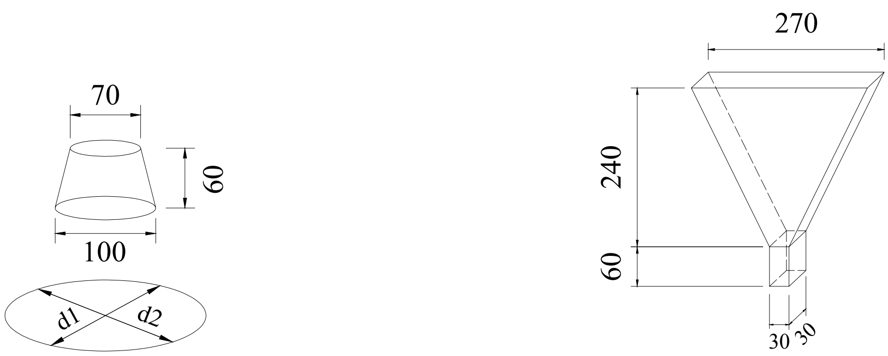
Those apparatus are:

1- Abram's cone was used to measure the slump flow of SCC

2- V-funnel as shown in Fig.4.2.2 was used to measure the flow time of SCC

3- Box-shaped container as shown in Fig.4.2.3 was used to measure the passing ability through obstacles of reinforcement.

By applying Okamura's design method in order to find a good mix proportion for SCC two other apparatus were made to determine the dosage of superplasticizer and volumetric water-powder ratio. One apparatus was used to measure the slump flow of mortar and the other apparatus was used to measure the flow time of mortar (Fig.4.2.4).



Relative flow area = (d1.d2/10000) -1

Mortar slump flow test

Relative funnel speed = 10/flow time (in seconds)

Mortar V-funnel test

Figure 4.2.4: Fresh mortar testing apparatus (Unit: mm)

4.2.6- Mixer

The tilting drum mixer as shown in Fig.4.2.5 is the popular mixer type in Cambodia. This type of mixer with effective capacity of 50 liters is available in the laboratory of Civil Engineering Department of ITC. It was decided to be used in the experiment.

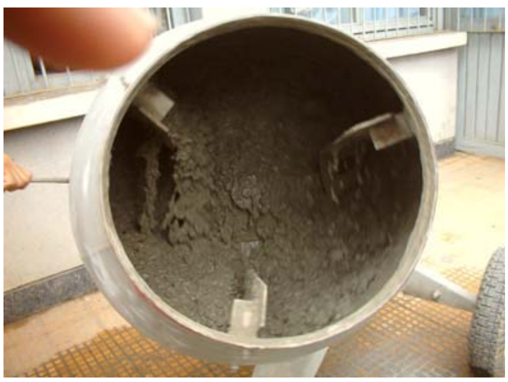


Fig.4.2.5 Tilting drum mixer

4.3- Experiment

4.3.1- Mix design

The mix design is based on experience from Japan in which two famous methods have been used. One is the JSCE method which is suitable for the materials in that country and another was proposed by Okamura et al. in 1993 which was accepted by many countries over the world. This method is based on the assumptions that moderate-heat Portland cement or belite-rich Portland cement is the only source of powder material. Coarse aggregate volume is fixed at 50% of its solid volume (G_{lim}) in concrete excluding air. Fine aggregate volume is determined at 40% of the mortar volume where the particle smaller than 0.09mm are not considered as aggregate but as powder. The volumetric water to powder ratio has to be determined by tests on mortar at which the relative flow area is 5 and the relative funnel speed is 1 (Fig.4.2.4). Superplasticizer dosage is roughly estimated by the mortar tests mentioned above.

3.3.2- Mixing

Generally mixing times for SCC need to be longer than for conventional mixes. In this research, mixing was made through the procedure as shown in Fig.4.3.1

$$\boxed{S + C + LF} \xrightarrow{2} \boxed{+\,W1} \xrightarrow{2} \boxed{+\,SP + W2} \xrightarrow{3} \boxed{+\,G} \xrightarrow{3} \boxed{SCC}$$

Fig.4.3.1: Mixing procedure

Note: W1 = 70% of total water
W2 = 30% of total water

4.3.3- Slump flow test

The procedure of doing this test was made according to recommendation of Japanese Society of Civil Engineering for self-compacting concrete. A slump cone in the shape of a truncated cone with the internal dimensions 200mm diameter at the base, 100mm diameter at the top and a height of 300mm, conforming to JIS A 1101, was used to measure the slump flow.

4.3.4- V-funnel test

The procedure of doing this test was made according to recommendation of Japanese Society of Civil Engineering for self-compacting concrete. V-funnel was used to measure the flow time of fresh concrete.

4.3.5- Box-shaped container test

The procedure of doing this test was made according to recommendation of Japanese Society of Civil Engineering for self-compacting concrete. This test was used to judge the requirement of passing ability.

4.3.6- Compressive strength test

The Walter & Bai compressive machine with the capacity of 3000kN was used to test the compressive strength. This machine is made in Switzerland. The compressive strength was tested at the age of 3days and 28days. The specimen was cylinder of 100mm diameter and 200mm height.

4.3.7- Results and discussions

The results of trial mixes are given in Table 4.3.7.1 and the mix design specification is shown in Table 4.3.7.2. As can be seen, many mix proportions could achieve the requirement of flowing without segregation (slump flow and funnel test).

Table 4.3.7.1: test results of trial mix proportions

No	Type of G	W	C	LF	S	G	SP	Slump flow	Funnel	Box
		kg	Kg	kg	kg	Kg	kg	mm	s	mm
1	GB	161.6	413.7	190.9	840.6	791.1	6.047	675	105.00	90
2	GB	161.6	413.7	190.9	840.6	791.1	4.837	595	90.00	100
3	GB	183.8	418.0	192.9	849.3	716.6	4.888	800	19.00	200
4	GB	181.5	424.7	196.0	862.8	700.0	4.965	770	22.00	220
5	GB	183.8	418.0	192.9	849.3	716.6	4.277	740	11.14	275
6	GB	183.8	418.0	192.9	849.3	716.6	3.666	670	11.22	272
7	GB	185.7	422.4	195.0	777.8	779.9	3.704	680	11.00	170
8	GB	175.4	422.4	195.0	858.3	724.2	3.704	538	24.00	125
9	GB	196.0	422.4	222.8	777.8	724.2	3.872	775	15.65	220
10	GB	196.0	422.4	222.8	777.8	724.2	3.226	685	15.20	210
11	GB	187.7	426.9	225.2	786.1	731.9	3.913	655	7.65	280
12	GS	187.7	426.9	225.2	786.1	731.9	3.913	665	7.46	320
13	GS	181.9	413.7	218.2	761.8	791.1	3.792	660	14.00	200
14	GB	189.7	431.5	227.6	794.5	711.3	3.955	735	4.00	290
15	GB	185.7	422.4	195.0	831.5	724.2	3.704	680	6.55	150
16	GB	187.7	426.9	197.0	704.8	844.5	3.120	615	9.66	50
17	GB	162.7	429.1	109.8	872.2	823.4	5.389	628	28.52	90
18	GB	202.5	460.7	212.6	760.5	702.0	2.693	670	6.21	298

But to achieve one more condition, no blocking at the reinforcements which measured by box-shaped container, was very difficult to satisfy: only mixes 12 and 18 could be verified. This problem was caused by the characteristic of coarse aggregates whose shape was not well rounded to flow freely around reinforcements and its grading was not good: its content must be less than that of good grading aggregates. Air content had been measured in several mixes and it was found around 2%, which was fixed in the mix design.

Table 4.3.7.2: mix design specification

Slump flow	Funnel	Box
mm	s	mm
650 ± 50	10 ± 5	≥ 300

As described above, the difficulty of achieving the self-compacting degree of passing ability through obstacles of reinforcement was due to the effects of the characteristics of the coarse aggregate.

In mixes 11 and 12, the same mix proportions with two different grading types of coarse aggregate were tried. The detail of these mix proportions is given in Table 4.3.7.3. The mix using the coarse aggregate GB was shown that fresh concrete could not pass well through the obstacles of reinforcement (box test = 28cm), but it showed to flow freely when the coarse aggregate of GS was used (box test = 32cm).

By keeping the same properties of mortar, another mix was tried with increasing the coarse aggregate content of GS until 56.68% of its solid volume in concrete as shown in Table 4.3.7.4. It was seen that the fresh concrete could not flow through the obstacles (box test = 20cm). This means that coarse aggregate content is strictly determined in order to get the passing ability around the reinforcements.

Another mix proportion was shown in Table 4.3.7.5 that the coarse aggregate GB content was fixed at 50.30% of solid volume of concrete and sand content was fixed at 40.63% of mortar. In this case the properties of fresh concrete was satisfied in all conditions of its fresh performance, flow ability, high resistance to segregation and passing ability around reinforcement bars.

When the coarse aggregate content was fixed at 50% of its solid volume in concrete and sand content was fixed at 40% of mortar even though the grading was not good, the self compact ability was also reached. It means that the design method proposed by Okamura et al. in 1993 is also well-applied with the raw materials in Cambodia.

Slump flow of one mix with ratio W/P=0.80 by volume was measured with the time. Just after mixing, slump flow was 600mm and it remained 420mm after 20 minutes. It was shown to be decreased in short time in the hot weather. Compressive strength was tested at the age of 3days and 28days. Size of specimen was cylinder of 100mm diameters and 200mm heights.

Table 4.3.7.3: detail of mixes number 11 and 12

Description	W	C	LF	S	G	SP	Air
Mass (kg/m^3)	187.7	426.9	225.2	786.1	731.9	3.913	
Volume (m^3/m^3)	0.188	0.136	0.083	0.302	0.271		0.020
Volume of mortar (m^3/m^3)	0.709				G/G_{lim} (%)		
Fraction in mortar (%)	26.47	19.12	11.76	42.65	52.44		

W/P (P = C+LF)		W/C	SP/P	S/(S+G)
by volume	by mass	by mass	%	by mass
0.86	0.29	0.44	0.6	0.52

Type of G	Slump flow	Funnel	Box	Compressive strength	
	mm	s	mm	3 days (MPa)	28 days (MPa)
GB	655	7.65	280	32.2	46.0
GS	665	7.46	320	34.4	50.5

Table 4.3.7.4: detail of mix number 13

Description	W	C	LF	S	G	SP	Air
Mass (kg/m^3)	181.9	413.7	218.2	761.8	791.1	3.792	
Volume (m^3/m^3)	0.182	0.131	0.081	0.293	0.293		0.020
Volume of mortar (m^3/m^3)	0.687				G/G_{lim} (%)		
Fraction in mortar (%)	26.47	19.12	11.76	42.65	56.68		

W/P (P = C+LF)		W/C	SP/P	S/(S+G)
by volume	by mass	by mass	%	by mass
0.86	0.29	0.44	0.6	0.49

Type of G	Slump flow	Funnel	Box	Compressive strength	
	mm	s	mm	3 days (MPa)	28 days (MPa)
GS	660	14.00	200	38.6	55.0

Table 4.3.7.5: detail of mix number 18

Description	W	C	LF	S	G	SP	Air
Mass (kg/m^3)	202.5	460.7	212.6	760.5	702.0	2.693	
Volume (m^3/m^3)	0.203	0.146	0.079	0.293	0.260		0.020
Volume of mortar (m^3/m^3)	0.720				G/G$_{lim}$ (%)		
Fraction in mortar (%)	28.13	20.31	10.94	40.63	50.30		

W/P (P = C+LF)		W/C	SP/P	S/(S+G)
by volume	by mass	by mass	%	by mass
0.90	0.30	0.44	0.4	0.52

Type of G	Slump flow	Funnel	Box	Compressive strength	
	mm	s	mm	3 days (MPa)	28 days (MPa)
GB	670	6.21	298	31.5	50.2

CHAPTER 5: EXPERIMENTS ON PRESTRESS LOSS

5.1- General

To clarify the design in above chapter, an experiment was carried out on one selected PC girder at Maeda precast plant Phnom Penh office. Because the experience on prestress loss in SCC is still limited until now, prestress loss was investigated in this experiment.

SCC was designed to get the basic design strength 60MPa at 28 days and 40MPa at transfer day. Mix proportion is shown in Table 5.1.1.

The prestress loss was measured by indirect method. The camber and strains on concrete along the PC girder at the location of prestressing tendon were measured. With this measurement method, only the prestress loss due to creep and shrinkage could be investigated. The loss due to relaxation is supposed by using equation (4.5.3.5).

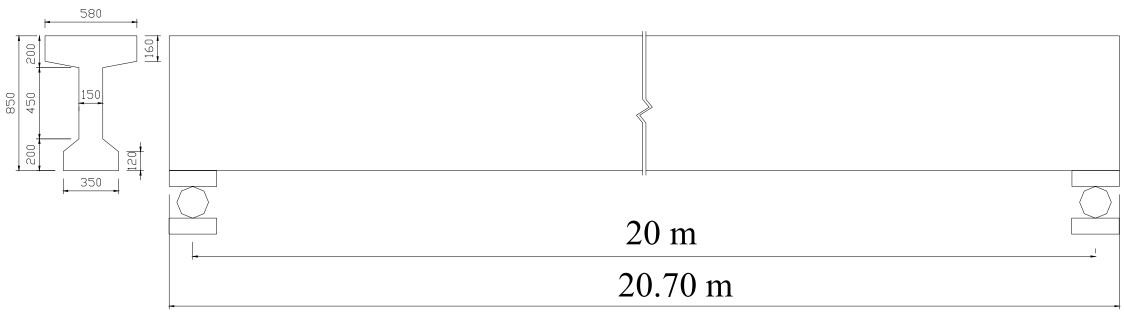


Fig.5.1.1: Specimen

Table 5.1.1: Mix proportion

<table>
<tr><th rowspan="3">#</th><th rowspan="3">A</th><th rowspan="3">G</th><th colspan="4">Mortar</th><th rowspan="2">SP</th><th rowspan="3">W/C</th><th rowspan="3">W/P</th></tr>
<tr><th rowspan="2">S</th><th colspan="2">P</th><th rowspan="2">W</th></tr>
<tr><th>C</th><th>LF</th><th>%P</th></tr>
<tr><td rowspan="4">Volume</td><td rowspan="4">0.02</td><td rowspan="4">0.28</td><td colspan="4">0.7</td><td rowspan="4">1</td><td rowspan="4">0.33</td><td rowspan="4">0.8</td></tr>
<tr><td rowspan="3">0.315</td><td colspan="3">0.385</td></tr>
<tr><td colspan="2">0.214</td><td rowspan="2">0.171</td></tr>
<tr><td>0.165</td><td>0.049</td></tr>
<tr><td>Density</td><td>-</td><td>2.74</td><td>2.63</td><td>3.15</td><td>2.7</td><td>1</td><td>By Mass</td><td>By Mass</td><td>By Volume</td></tr>
<tr><td>Mass</td><td>-</td><td>767.2</td><td>828.5</td><td>518.5</td><td>133.1</td><td>171.1</td><td>6.516</td><td></td><td></td></tr>
</table>

Fig.5.1.2 shows the position of PC strands and some PC strands were debonded at the end parts of girder. Drawing of reinforcement is given in Fig.5.1.3.

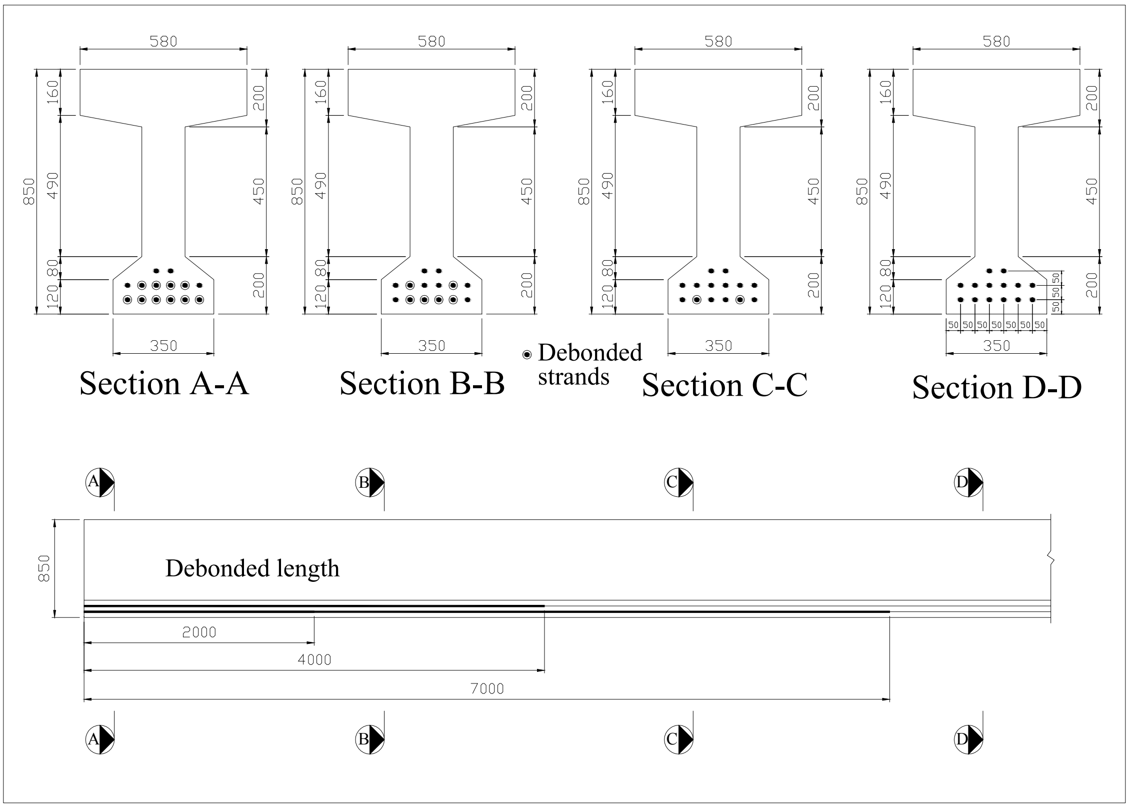


Fig.5.1.2: Position of PC strands

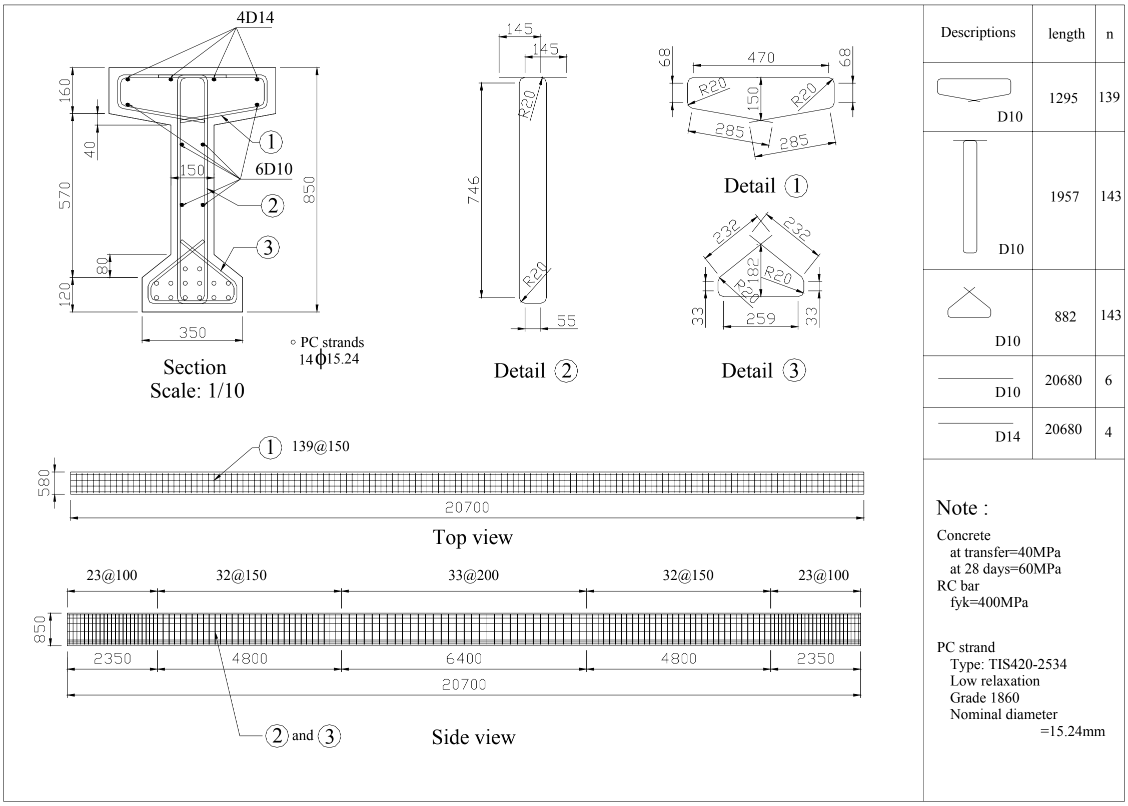


Fig.5.1.3: Drawing of reinforcement

Stresses on concrete at lower and upper surfaces were calculated in 0.5m step along girder without consideration of transferring prestressing force effect as shown in Table 5.1.2 for stress limit verification.

Table 5.1.2: Stress verifications

x	Bonded	Pi	e_0	e_s	M0	Ms	$\sigma_{\chi ito}$	σ_{csto}	σ_{citt}	σ_{cstt}
m	strands	kN	cm	cm	kNm	kNm	MPa	MPa	MPa	MPa
0.0	4	571	36.3	36.3	0.0	0.0	7.61	-1.45	6.09	-1.16
0.5	4	571	36.3	36.3	28.3	73.3	6.90	-0.92	4.25	0.21
1.0	4	571	36.3	36.3	55.1	144.1	6.23	-0.42	2.48	1.52
1.5	4	571	36.3	36.3	80.5	212.3	5.59	0.05	0.77	2.79
2.0-	4	571	36.3	36.3	104.4	278.0	4.99	0.50	-0.88	4.01
2.0+	8	1143	38.8	38.8	104.4	278.0	13.32	-1.48	5.78	2.43
2.5	8	1143	38.8	38.8	126.9	341.2	12.76	-1.06	4.20	3.61
3.0	8	1143	38.8	38.8	147.9	401.8	12.23	-0.67	2.68	4.74
3.5	8	1143	38.8	38.8	167.5	459.9	11.74	-0.31	1.22	5.82
4.0-	8	1143	38.8	38.8	185.6	515.4	11.29	0.03	-0.17	6.85
4.0+	12	1714	39.6	39.6	185.6	515.4	19.61	-1.95	6.49	5.27
4.5	12	1714	39.6	39.6	202.3	568.4	19.19	-1.64	5.16	6.25
5.0	12	1714	39.6	39.6	217.5	618.9	18.81	-1.35	3.90	7.19
5.5	12	1714	39.6	39.6	231.3	666.8	18.47	-1.10	2.70	8.08
6.0	12	1714	39.6	39.6	243.6	712.2	18.16	-0.87	1.56	8.93
6.5	12	1714	39.6	39.6	254.5	755.0	17.89	-0.67	0.49	9.72
7.0-	12	1714	39.6	39.6	263.9	795.3	17.65	-0.49	-0.52	10.47
7.0+	14	2000	40.2	40.2	263.9	795.3	21.99	-1.61	2.95	9.58
7.5	14	2000	40.2	40.2	271.9	833.1	21.79	-1.46	2.00	10.28
8.0	14	2000	40.2	40.2	278.4	868.3	21.63	-1.34	1.12	10.93
8.5	14	2000	40.2	40.2	283.5	900.9	21.50	-1.25	0.30	11.54
9.0	14	2000	40.2	40.2	287.1	931.1	21.41	-1.18	-0.45	12.10
9.5	14	2000	40.2	40.2	289.3	958.7	21.36	-1.14	-1.14	12.61
10.0	14	2000	40.2	40.2	290.0	983.7	21.34	-1.13	-1.77	13.08

Ultimate bending moment was calculate for the verification and the result is shown in Fig.5.1.3.

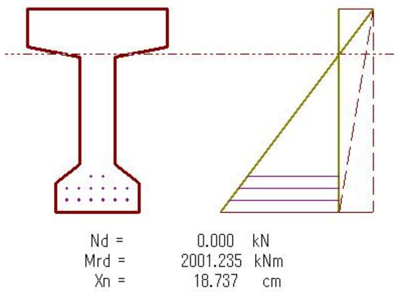


Fig.5.1.3: Ultimate bending moment

5.2- Experiment setting

A prestressing yard was made for the experiment purpose as can be seen in Fig.5.2.1. Formwork was made by steel plate as shown in Fig.5.2.2. Flexible pipe of 20mm inside diameter was used as debonded materials.

Fig.5.2.1 Prestressing yard

Fig.5.2.2: Formwork

The hydraulic jack of maximum 20 tons of capacity was used to tension the PC strands. The jack was calibrated by dynamometer. Calibration curve is given in the graphic of Fig.5.2.3. The tension force was control by pressure gauge and verified by its elongation as shown in Fig.5.2.4 and Fig.5.2.5.

SCC was mixed in a batching plant located about 50km from casting yard. Before mixing the SCC, moisture content in aggregate was checked and mix proportion was adjusted.

Trial casting of SCC was made 1 day before the real casting to the girder specimen and the fresh properties of SCC were checked by slump flow test, V-funnel test and box-shape container test. At casting day, the fresh property of SCC was checked only by slump flow test just after mixing and before casting. Two truck mixer were transported the concrete from batching plant to casting yard about 60min and it took 30min to cast the concrete to the formwork. Just after concrete filled the formwork, finishing work as can be seen in Fig.5.2.7 was carried out to smooth the surface of specimen.

Formwork was removed after 1day of casting. PC girder was cured for 5 days by water as shown in Fig.5.2.8. PC strands were cut at 6 days to transfer the prestress force to SCC girder by releasing method. It means that cutting strands were operated one by one wire (each strand compose of 7 wires).

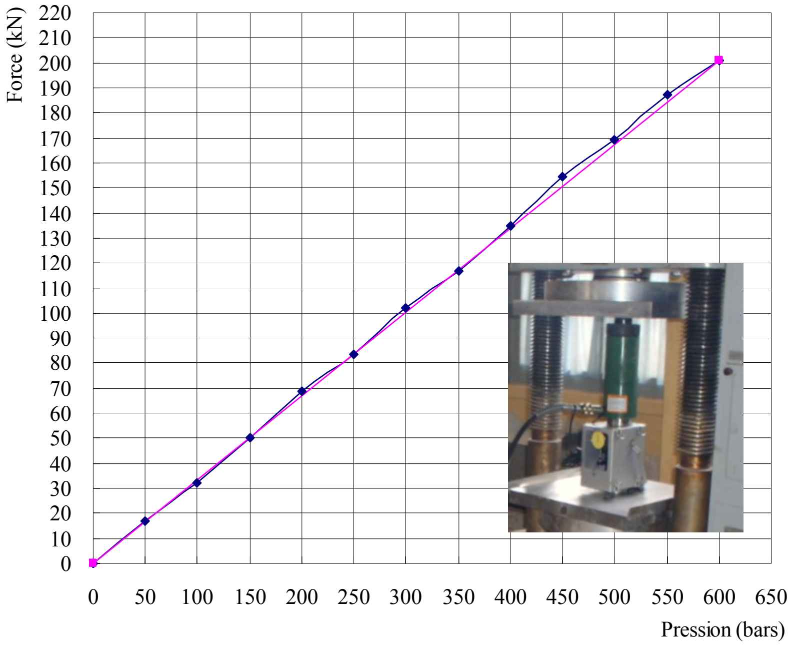


Fig.5.2.3: Calibration curve

Table.5.2.1: Fresh properties of SCC

SCC	SP used	Test	At batching plant	Just arrive at casting yard	Adjust SP	After adjusting
Trial casting	0.9%	Slump flow	675	510	0.2%	700
		V-funnel	-	-		10.12
		Box	-	-		302
Casting	1.0%	Slump flow	645	625	-	-
		V-funnel	-	14.93		-

By considering the loss at tensioning and the loss at transferring due to elastic shortening, the PC strands were tensioned at total force 2279kN. After loss due to settlement of wedge the total tension force remains 2227kN.

Fig.5.2.4: Tensioning PC strands

Fig.5.2.5: Measurement of strand elongation

Fig.5.2.6: Casting SCC

Fig.5.2.7: Finishing

Compressive strength of concrete was tested on the age of transfer (6 days) and 28 days by using the specimen of cylinder 100x200mm.

Fig.5.2.8: Curing

Fig.5.2.9: SCC PC girder

5.3- Strains and deflection measurement

Strains on concrete were measured by contact gauge meter of 300mm of base. Contact point gauges were pasted on PC girder as shown in Fig.5.3.2. The measurement was made just before cutting strands, just after cutting strands and after cutting strands 1 day, 3days, 7 days, 14 days, 21 days, 28 days and 56 days.

At the same time of strain measurement, the cambers were measured at 20 points on both side of the bottom surface of PC girder.

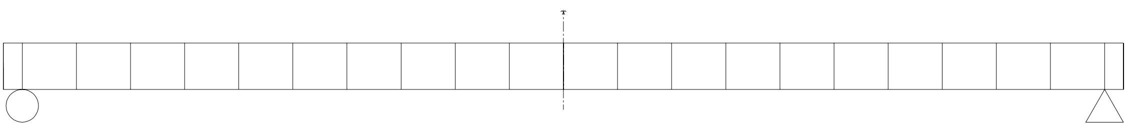


Fig.5.3.1: Position of deflection measurement

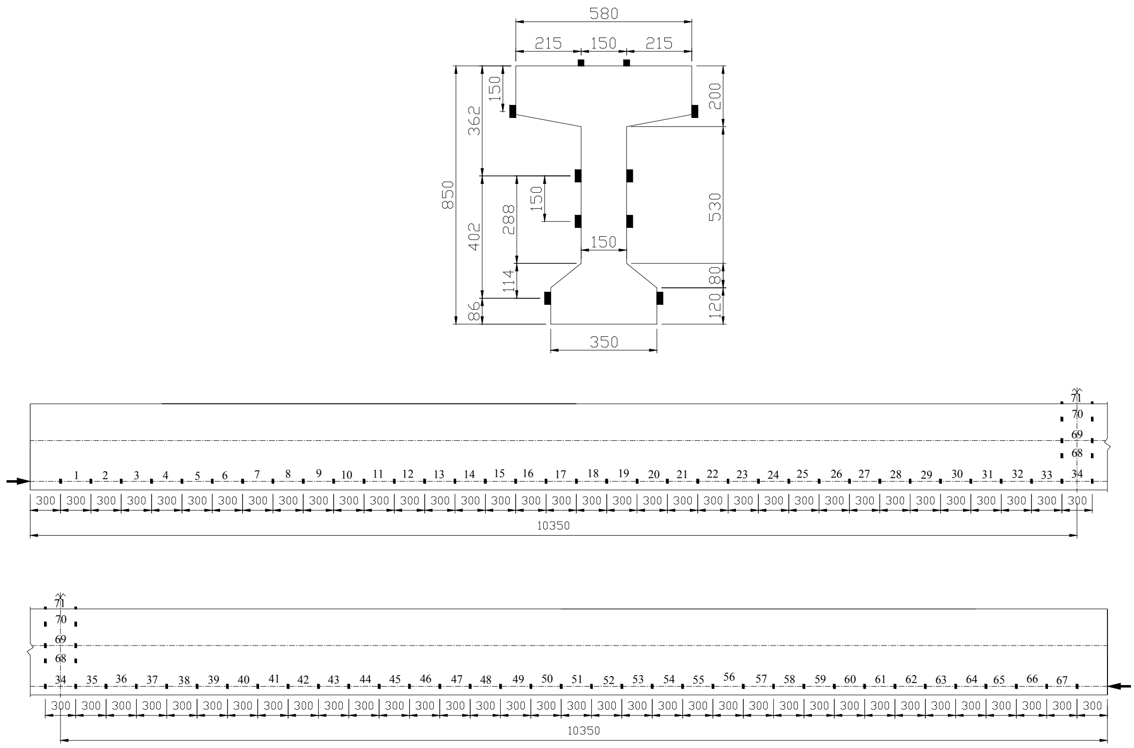


Fig.5.3.2: Position of contact point gauges

5.4- Results and discussion

Compressive strength is shown in Table 5.4.1. Experiment values of prestress loss were derived from the measured strains on the concrete at the location of PC strands. The loss due to relaxation was excluded from the experimental values.

The calculation of prestress loss was made by time step method with using the creep and shrinkage model given in JSCE2002 including the loss due to relaxation. The relative humidity was taken as 70%. The time dependent cambers along the PC girder were checked and the strains of concrete at the section of mid-span were also checked.

Three case studies are presented: one is the case without consideration of adhering force and friction force between the bottom of formwork and PC girder which appear at the transferring time and friction forces at the end of supports which appear at after transferring, another case these effects were included in the calculation and the final case, the effects of temperature were considered. Adhering stress was supposed as 0.05MPa and friction coefficient was supposed as 0.4. The creep and shrinkage models given in CEB-FIP90 with consideration of the environment temperature 20^{o}C and 28^{o}C were used to check the time dependent temperature cambers for the extra case.

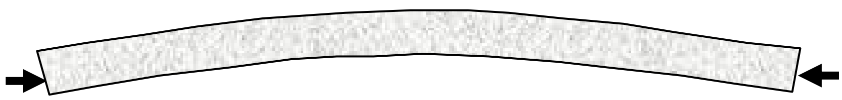
Table 5.4.1: Strength of concrete

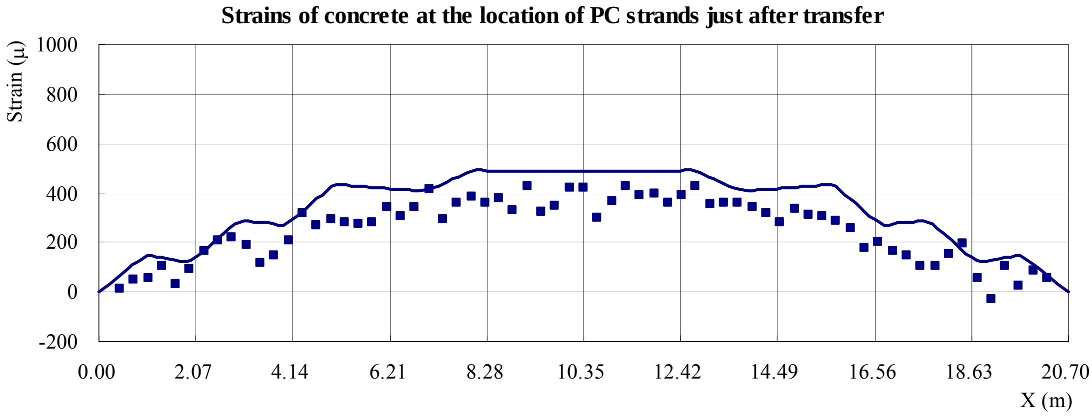
N	6 days (MPa)	28 days (MPa)
1	58.28	79.59
2	62.20	79.24
3	53.89	69.07
4	56.78	70.09
5	57.73	63.92
Mean	57.8	72.4

Case study 1:

At transfer

After transfer





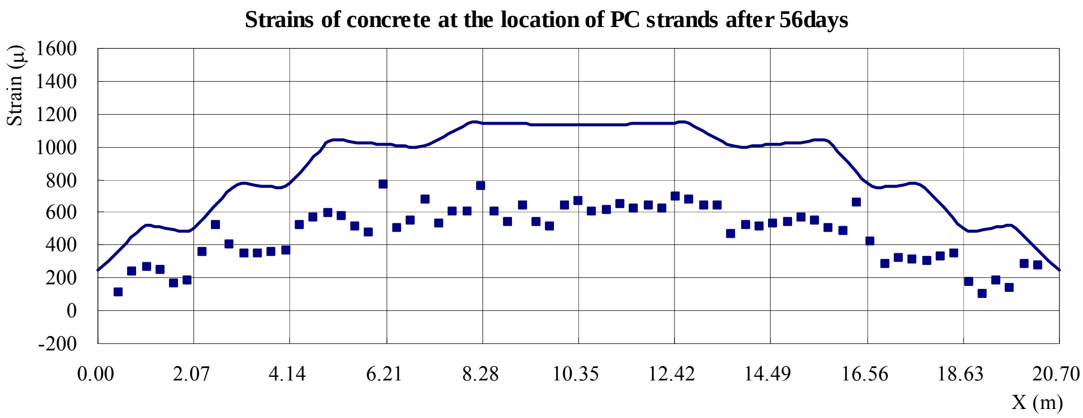


Fig.5.4.1: Strains of concrete at the location of PC strands

Table 5.4.2: Prestress loss at the middle part of PC girder

Date	Experiment (%)	Calculation (%)
Just after transfer	6.78	8.71
After 56 days of transfer	2.36	12.96

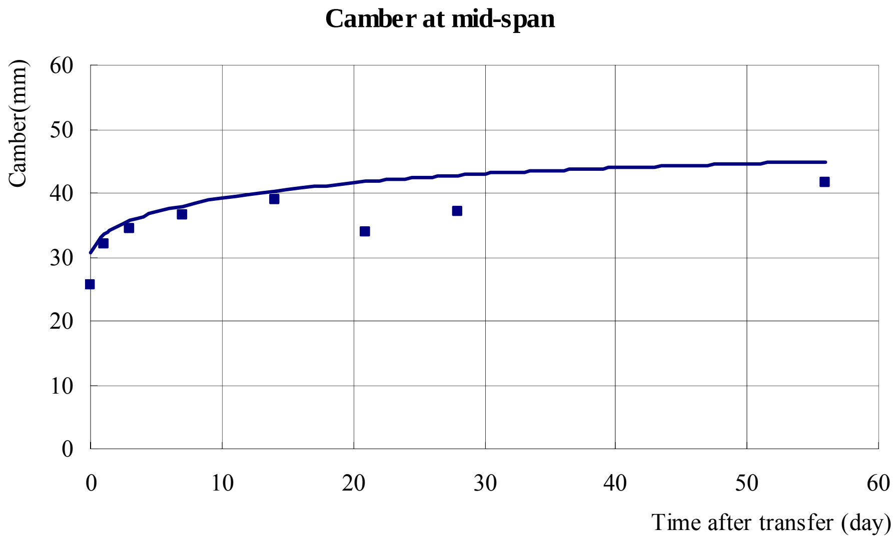
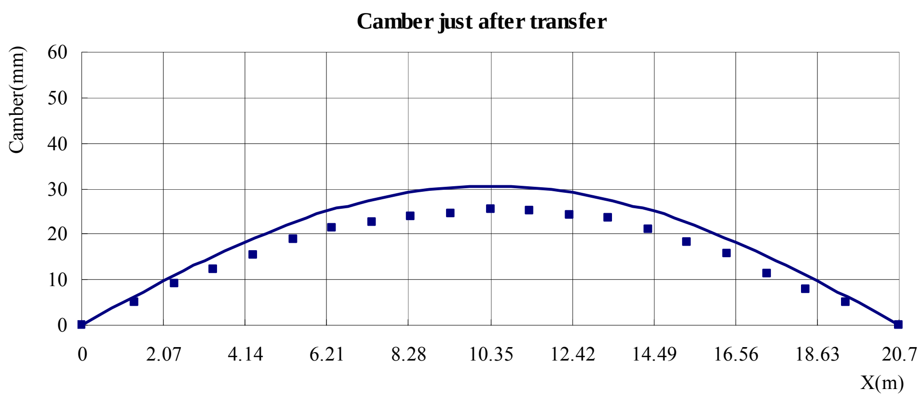
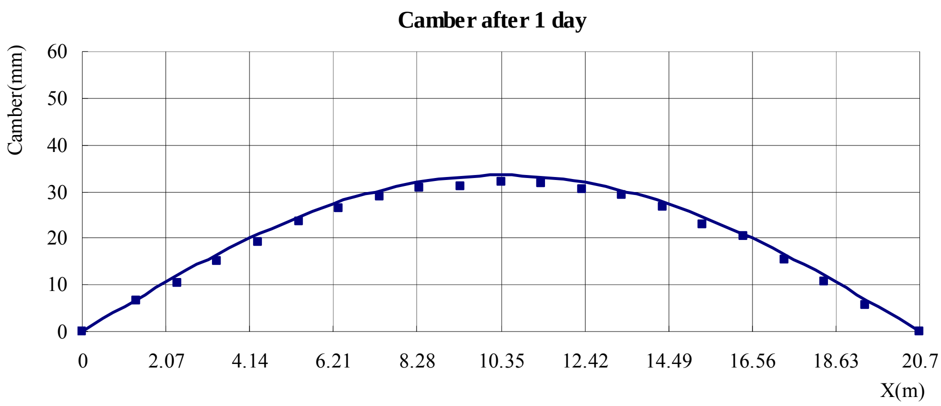
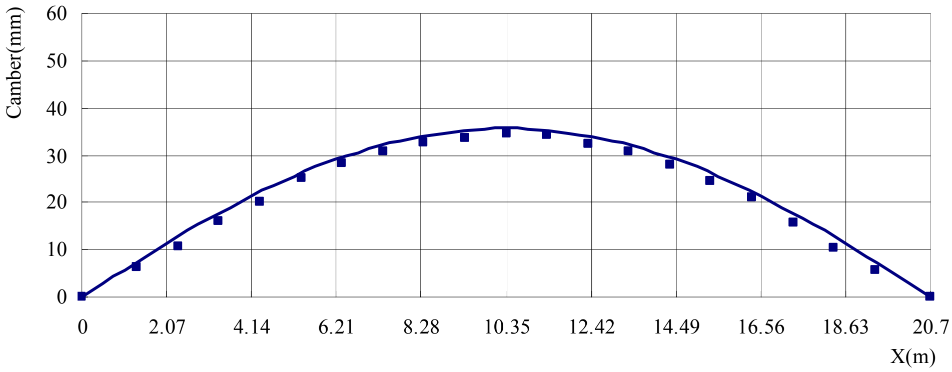


Fig.5.4.2: Time dependent camber at mid-span

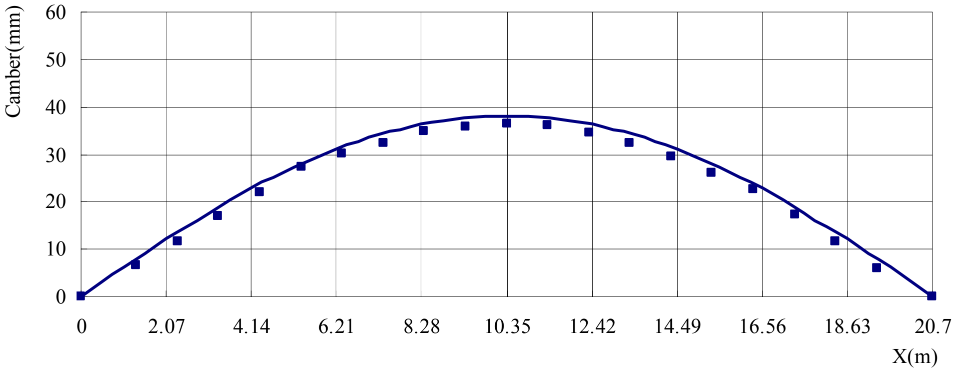




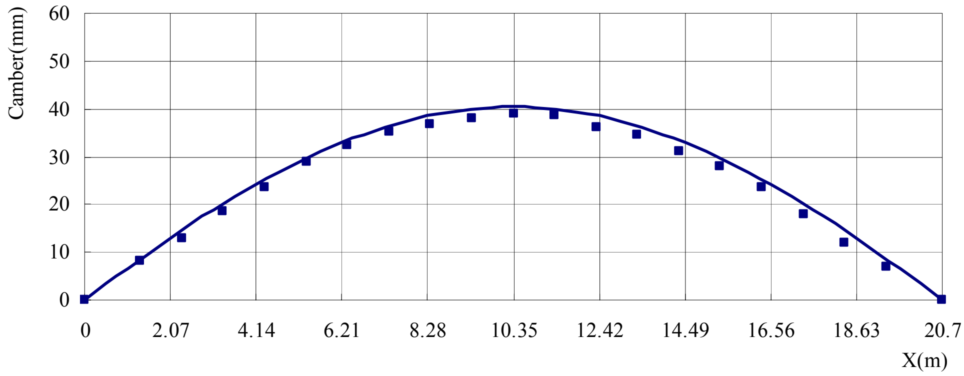
Camber after 3 days



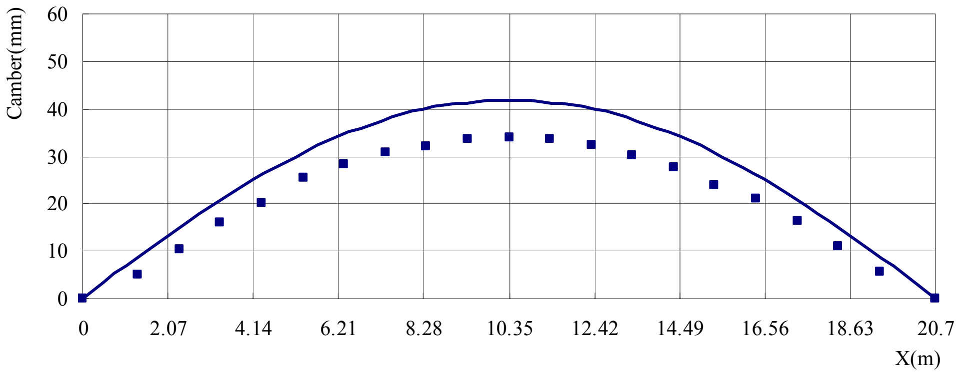
Camber after 7 days



Camber after 14 days



Camber after 21 days



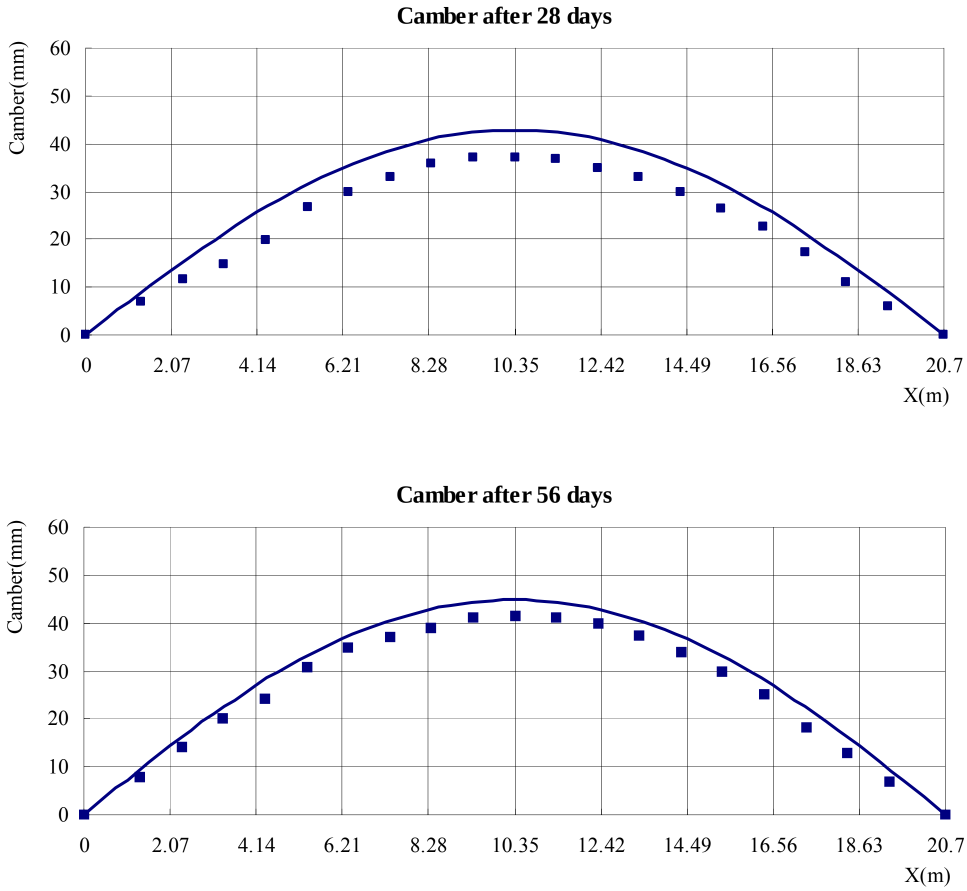
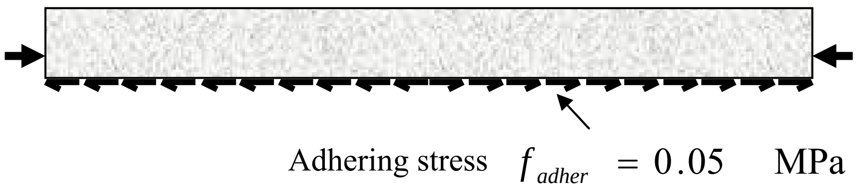


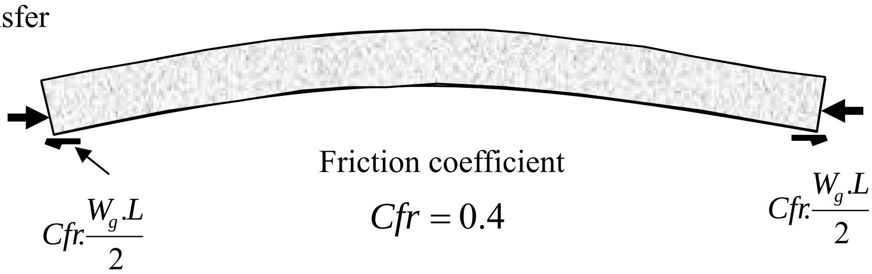
Fig.5.4.3: Time dependent camber along the PC girder

Case study 2:

At transfer



After transfer



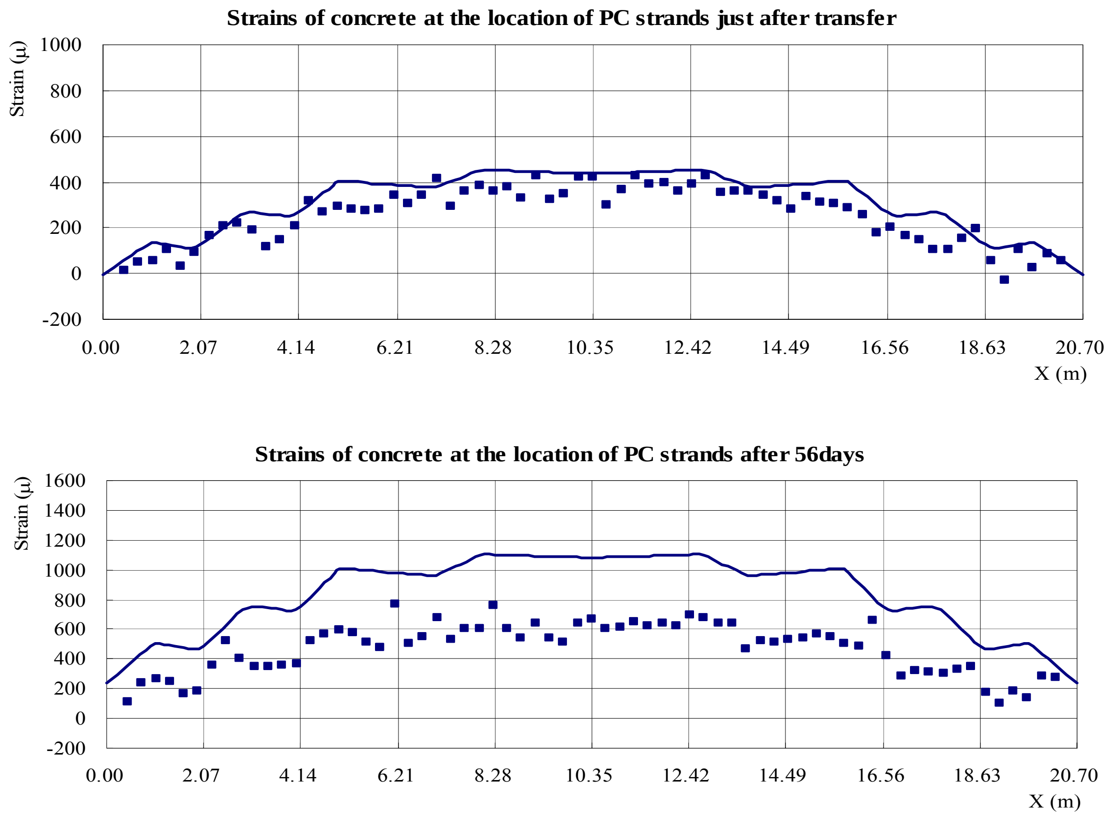


Fig.5.4.4: Strains of concrete at the location of PC strands

Table 5.4.3: Prestress loss at the middle part of PC girder

Date	Experiment (%)	Calculation (%)
Just after transfer	6.78	7.94
After 56 days of transfer	2.36	12.75

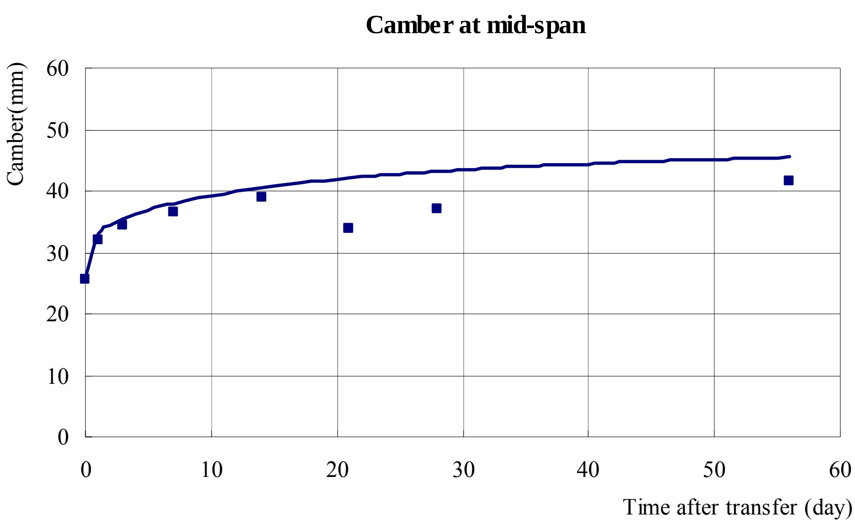


Fig.5.4.5: Time dependent camber at mid-span of PC girder

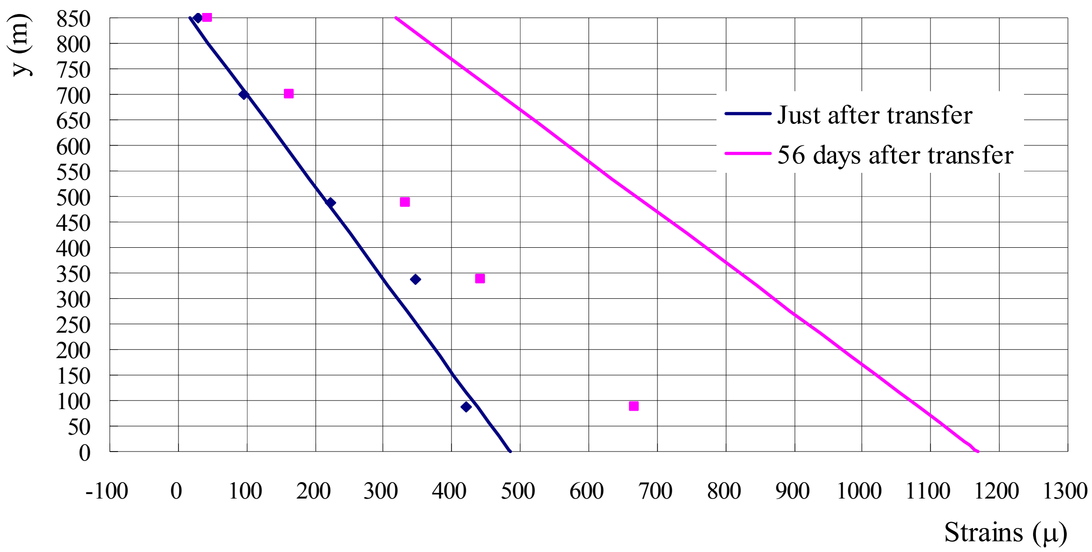


Fig.5.4.6: Distribution of concrete strains at the section of mid-span of PC girder

As can be seen in Fig.5.4.4 and Fig.5.4.6, prestress loss and distribution of strains of concrete at the mid-span section at 56 days shows quite lower compared with the calculation. One reason can be said that because the calculation values of prestress loss was made by many assumptions such as using beam theory of section plane remain plane after deformation, using existing linear creep and shrinkage models and prediction of elastic modulus of concrete by its strength.

Case study 3:

The climate data at the time of experiment given in graphics of the Fig.5.4.7 was obtained from Pochentong Meteorology station. This case study shows the change of PC girder properties due to the effect of temperature. The assumption was set for the study which describes in the following explanations.

Thermal expansion of concrete was taken as 0.00001 /^{o}C. By considering the expansion of PC steel the same as the concrete, the variation of temperature does not affect the prestress loss. But it makes the change of the measured values of prestress loss.

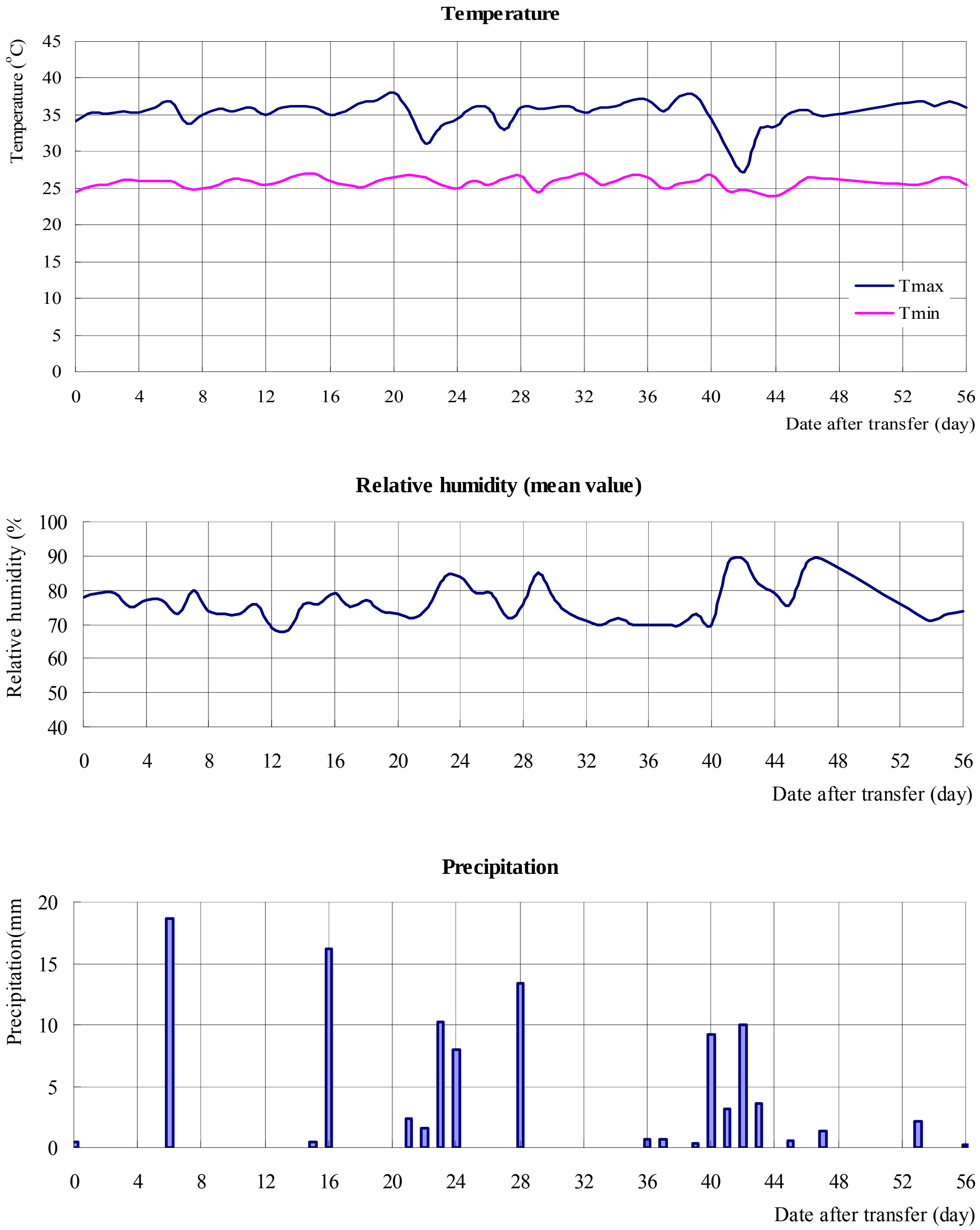
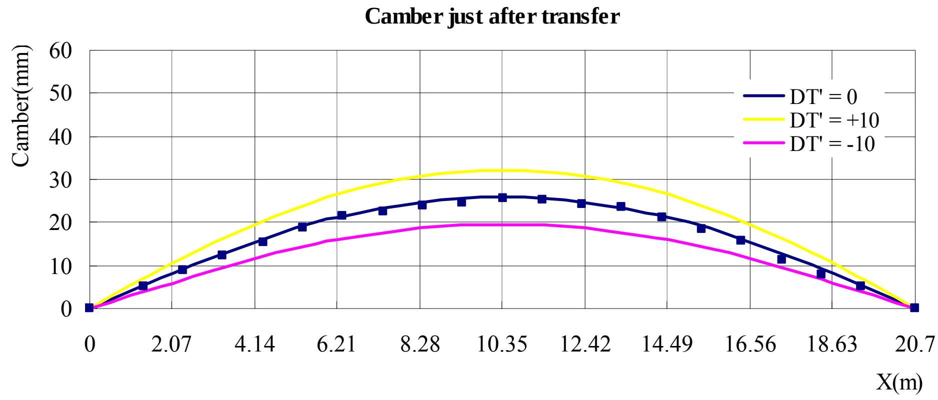
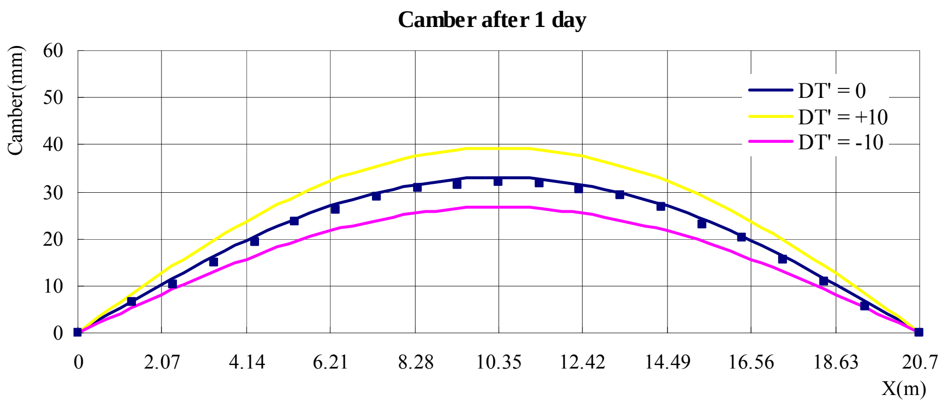
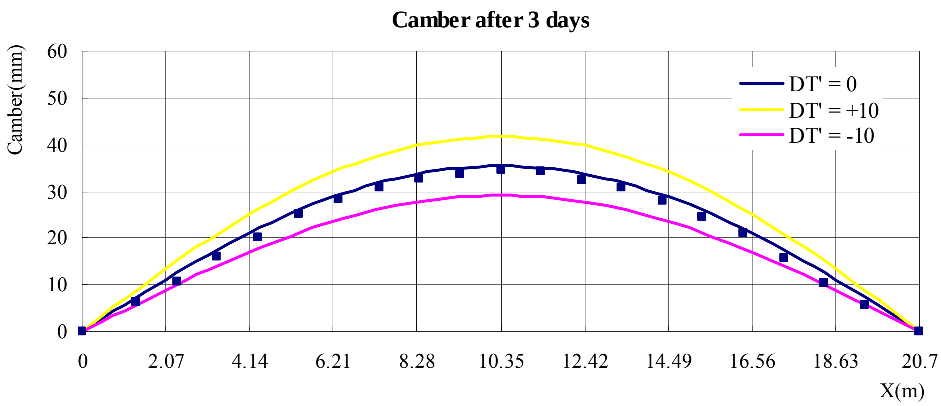


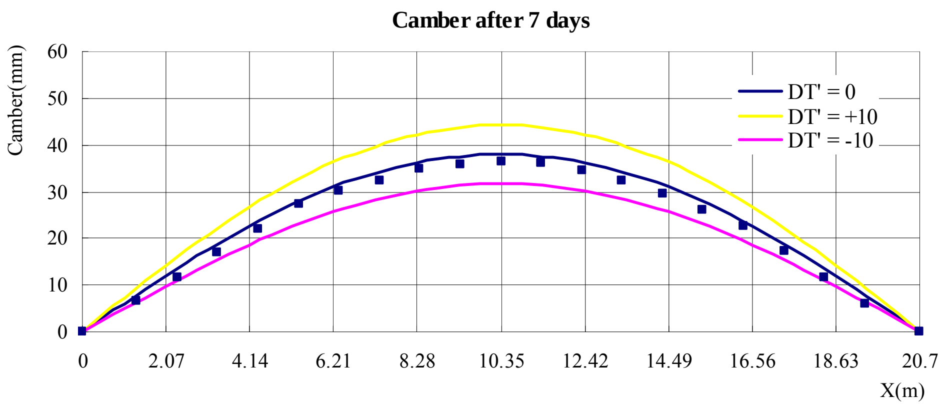
Fig.5.4.7: Climate data at the time of experiment

Supposing the variation of temperature as ±5°C, the change of the measured value of prestress loss is ±100MPa (- means prestress gain). The camber affected by temperature was calculated by assuming that the temperature differential from top to bottom was ±10°C.


Camber just after transfer
Camber(mm)
60
50
40
30
20
10
0
0
2.07
4.14
6.21
8.28
10.35
12.42
14.49
16.56
18.63
20.7
X(m)
DT' = 0
DT' = +10
DT' = -10


Camber after 1 day
Camber(mm)
60
50
40
30
20
10
0
0
2.07
4.14
6.21
8.28
10.35
12.42
14.49
16.56
18.63
20.7
X(m)
DT' = 0
DT' = +10
DT' = -10


Camber after 3 days
Camber(mm)
60
50
40
30
20
10
0
0
2.07
4.14
6.21
8.28
10.35
12.42
14.49
16.56
18.63
20.7
X(m)
DT' = 0
DT' = +10
DT' = -10


Camber after 7 days
Camber(mm)
60
50
40
30
20
10
0
0
2.07
4.14
6.21
8.28
10.35
12.42
14.49
16.56
18.63
20.7
X(m)
DT' = 0
DT' = +10
DT' = -10

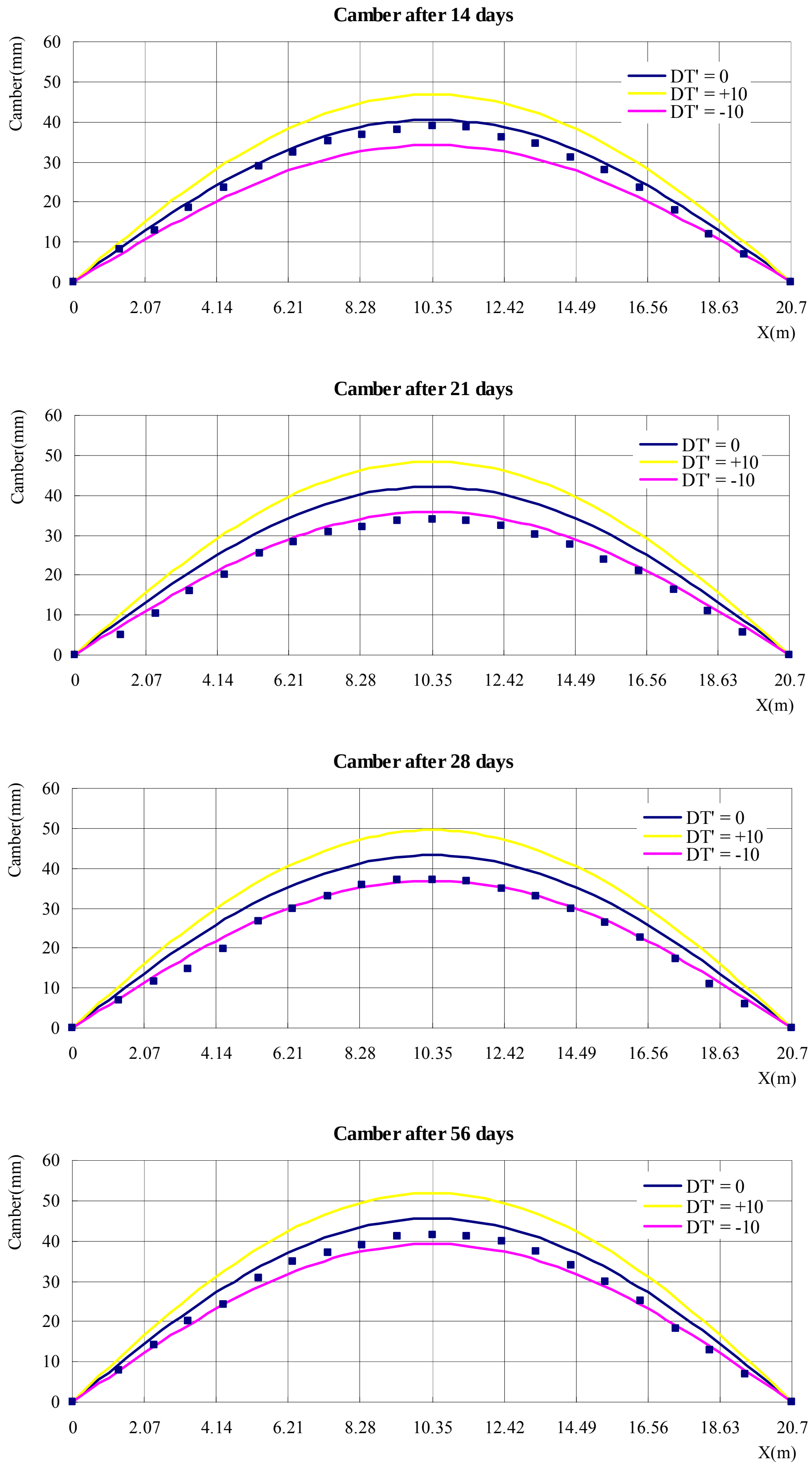


Fig.5.4.8: Camber along PC girder with consideration of temperature effects

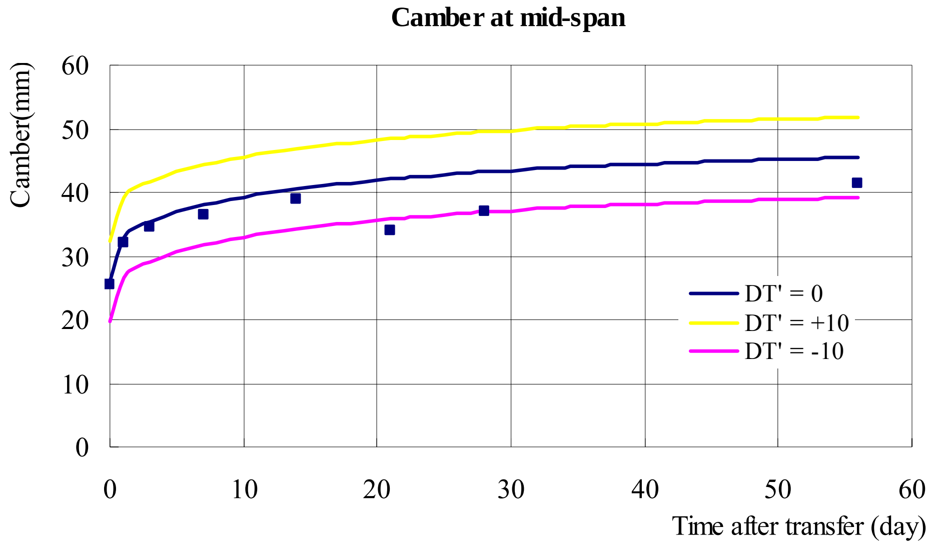


Fig.5.4.9: Camber at mid-span of PC girder with consideration of temperature effect

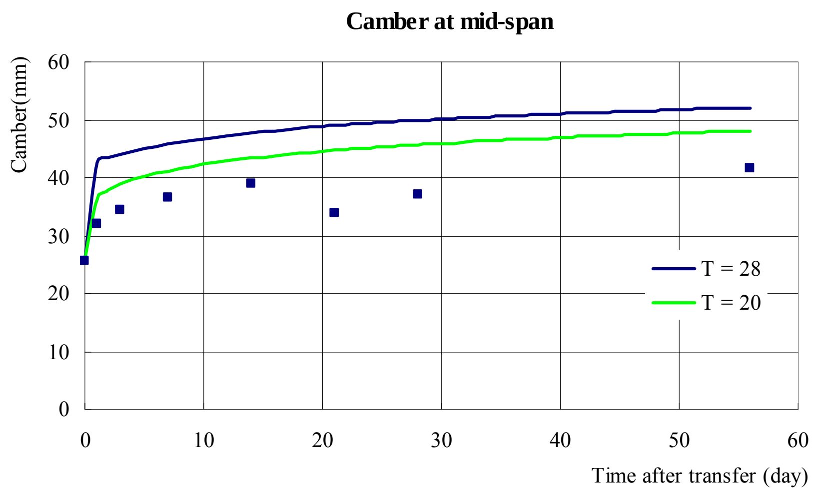


Fig.5.4.10: Camber at mid-span by using CEB-FIP90 code

All case studies above show that PC girder is in the safety condition. It means that existing models of creep and shrinkage can be used for predicting prestress loss in PC girder using self-compacting concrete in Cambodia. This experiment clarified the possibility of producing good quality prestressed concrete girder with Cambodian local materials and the design of PC girder presented in Chapter 3.

CHAPTER 6: CONCLUSIONS

In this research, the author found the successful way in producing SCC by using the available local materials in Cambodia. Further, the author develop the design standards and construction method for PC girder using SCC suiting for the local technical level, traffic conditions and climatic situation for the rehabilitation and construction of short span bridges in Cambodia. A real scale PC girder using SCC was also produced in order to validate the research outcome. The experiment showed that the proposed technology can successfully be used in bridge rehabilitation and construction in Cambodia.

Traffic load model given in Japanese standard for bridge design was decided to be used in this study and the author concluded that it is equally applicable in Cambodian environment. Self-weight of precast prestressed concrete girder was limited at 12 tons for the present time due to the conditions of transporting and moving the girder for construction.

The studies can be concluded as follows:

(1) Low weight prestressed concrete girder using self-compacting concrete for Cambodia at present time can be produced by the combination of:

- Using T-shape with heavy bottom flange girder,
- Using high strength concrete,
- Applying high prestressing force,
- Minimizing the dimensions of PC girder section by using more number of girders.

(2) If much heavier girders could be transported to the construction sites and big capacity of construction equipment can be variable, it can be said that the required bridge graders cost and construction cost will be lower than the recommended method.

(3) Self-compacting concrete can be produced with available materials in the Cambodian market. Limestone powder produced in Cambodia is one of powder materials used for self-compacting concrete. Ordinary Portland cement using in Cambodia can be used for producing self-compacting concrete. Slump flow value decreased significantly in short time in this experiment.

(4) The test of creep and shrinkage of self-compacting showed that limestone powder content does not significantly effect on shrinkage. JSCE2002 shrinkage model which considers absolute water content as main parameter can be applied to self-compacting

concrete using limestone powder. Self-compacting concrete with higher limestone powder content shows higher creep and self-compacting concrete which was made by adding limestone powder content to conventional concrete shows higher creep than the conventional even the strength is considerably increased.

(5) The production of real scale prestressed concrete girder using self-compacting concrete in Cambodia had shown the possibility of producing good quality prestressed concrete girder with Cambodian local materials.

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14. Ministry of public work and transportation, 'Maximum weight limitation on transport vehicle circulating on road network in Cambodia', seminar documentation, 1999, in Khmer language.

Annex 1: Creep and shrinkage models

1- JSCE 2002 model

Model for normal strength concrete

Range of applicability

- $45\% \leq RH \leq 80\%$
- $130 kg/m^3 \leq W \leq 230\%$
- $100 mm \leq V/S \leq 300 mm$
- $3 days \leq t_0 \leq 90 days$
- $40\% \leq W/C \leq 65\%$
- $f'_c(28) \leq 55$ MPa
- $260 kg/m^3 \leq C \leq 500 kg/m^3$ (for creep condition)

Formulation

Shrinkage

$$\varepsilon'_{cs}(t,t_0) = \left[1-\exp\left\{-0.108(t-t_0)^{0.56}\right\}\right]\varepsilon'_{sh}$$

$$\varepsilon'_{sh} = -50 + 78\left\{1-\exp\left(\frac{RH}{100}\right)\right\} + 38\ln w - 5\left[\ln\left(\frac{v/s}{10}\right)\right]^2 \qquad (\text{x}10^{-5})$$

t_0 : starting drying concrete age

t_0 is replaced by $t = \sum_{i=1}^{n} \Delta t_i \exp\left[13.65 - \frac{4000}{273 + T(\Delta t_i)/T_0}\right]$

t is the temperature adjusted concrete age

Δt_i is the number of days where a temperature T prevails

$T(\Delta t_i)$ is the temperature (°C) during the time period Δt_i

$T_0 = 1^{o}C$

Creep

$$\varepsilon'_{cc}(t,t',t_0)/\sigma'_{cp} = \left[1-\exp\left\{-0.09(t-t')^{0.6}\right\}\right] x \varepsilon'_{cr}$$

$$\varepsilon'_{cr} = \varepsilon'_{bc} + \varepsilon'_{dc}$$

$$\varepsilon'_{bc} = 15(c+w)^{2.0}(w/c)^{2.4}\left\{\ln(t')\right\}^{-0.67} x 10^{-10}$$

$$\varepsilon'_{dc} = 4500(w/c)^{4.2}(c+w)^{1.4}\left[\ln\left(\frac{v/s}{10}\right)\right]^{-2.2}\left\{1-\frac{RH}{100}\right\}^{0.36} t_0^{-0.30} x 10^{-10}$$

Model for high strength concrete

Range of applicability

$$40\% \le RH \le 90\%$$
$$130kg/m^3 \le W \le 230\%$$
$$100mm \le V/S \le 300mm$$
$$f'_c(28) \le 80 \text{ MPa}$$
$$1day \le t_0 \le 98days$$
$$t_0 = 98days \quad \text{if } t_0 > 98days$$

Formulation

Shrinkage

$$\varepsilon'_{cs}(t,t_0) = \varepsilon'_{ds}(t,t_0) + \varepsilon'_{as}(t,t_0)$$

$$\varepsilon'_{ds}(t,t_0) = \frac{\varepsilon'_{ds\infty}.(t-t_0)}{\beta + (t-t_0)}$$

$$\beta = \frac{4W\sqrt{V/S}}{100 + 0.7t_0}$$

$$\varepsilon'_{ds\infty} = \frac{\varepsilon'_{ds\rho}}{1+\eta.t_0} \qquad (\text{x}10^{-6})$$

$$\varepsilon'_{ds\rho} = \frac{\alpha(1-RH/100)W}{1+150\exp\left\{-\dfrac{500}{f'_c(28)}\right\}}$$

$$\eta = 10^{-4}\left\{15\exp(0.007f'_c(28)) + 0.25W\right\}$$

$\alpha = 11$ normal and low heat cement

$\alpha = 15$ high early strength cement

$$\varepsilon'_{as}(t,t_0) = \varepsilon'_{as}(t) - \varepsilon'_{as}(t_0)$$

$$\varepsilon'_{as}(t) = \gamma\varepsilon'_{as\infty}\left[1-\exp\left\{-a(t-t_s)^b\right\}\right] \quad (\text{x}10^{-6})$$

$$\varepsilon'_{as\infty} = 3070\exp\left\{-7.2(W/C)\right\}$$

W/C	a	b
0.20	1.2	0.4
0.23	1.5	0.4
0.30	0.6	0.5
0.40	0.1	0.7
>=0.50	0.03	0.8

Creep

$$\varepsilon'_{cc}(t,t',t_0)/\sigma'_{cp} = \frac{4W(1-RH/100)+350}{12+f'_c(t')}\ln(t-t'+1)$$

2- CEB-FIP90 model

Range of applicability

- $12MPa \le f_{ck} \le 80MPa$
- $|\sigma_c| \le 0.6 f_{cm}(t_0)$
- $40\% \le RH \le 100\%$
- $0^\circ C < T < 80^\circ C$

The prediction model is not applicable to:

- Concrete subjected to extreme temperatures, high (e.g. nuclear reactors) or low (e.g. LNG-tanks)
- Very dry climatic conditions (average relative humidity RH < 40%)
- Structural lightweight aggregate concrete

Shrinkage

$$\varepsilon_{cs}(t,t_s) = \varepsilon_{cs0}.\beta_s(t-t_s)$$

$$\varepsilon_{cs0} = \varepsilon_s(f_{cm}).\beta_{RH}$$

$$\varepsilon_s(f_{cm}) = [160+10\beta_{sc}(9-f_{cm}/f_{cmo})].10^{-6}$$

Type of cement	32.5	32.5R 42.5	42.5R 52.5
β_{sc}	4	5	8

$$\beta_{RH} = \begin{cases} -1.55\beta_{sRH} & \text{for} \quad 40\% < \text{HR} < 99\% \\ +0.25 & \text{for} \quad \text{HR} > 99\% \end{cases}$$

$$\beta_{sRH} = 1-\left(\frac{RH}{RH_0}\right)^3$$

$$\beta_s(t-t_s) = \left(\frac{(t-t_s)/t_1}{350(h/h_0)^2+(t-t_s)/t_1}\right)^{0.5}$$

Effect of temperature

$$\alpha_{sT}(T) = 350\left(\frac{h}{h_0}\right)^2 \exp[-0.06(T/T_0-20)]$$

$\alpha_{sT}(T)$ replaces the product $350(h/h_0)^2$ in last equation

$\beta_{RH,T} = \beta_{RH}\beta_{sT}$ replaces β_{RH} in last equation

with $\beta_{sT} = 1 + \left(\dfrac{8}{103 - 100RH/RH_0}\right)\left(\dfrac{T/T_0 - 20}{40}\right)$

Creep

With the rang of service stresses $|\sigma_c| < 0.4 f_{cm}(t_0)$

$$\varepsilon_{cc}(t,t_0) = \frac{\sigma_c(t_0)}{E_{ci}}\phi(t,t_0)$$

$$J(t,t_0) = \frac{1}{E_c(t_0)} + \frac{\varphi(t,t_0)}{E_{ci}}$$

$$\varepsilon_{c\sigma}(t,t_0) = \sigma_c(t_0)\left[\frac{1}{E_c(t_0)} + \frac{\varphi(t,t_0)}{E_{ci}}\right] = \sigma_c(t_0)J(t,t_0)$$

$$\phi(t,t_0) = \phi_0(t_0).\beta_c(t - t_0)$$

$$\phi_0(t_0) = \phi_{RH}.\beta(f_{cm}).\beta(t_0)$$

$$\phi_{RH} = 1 + \frac{1 - RH/RH_0}{0.46.\sqrt[3]{h/h_0}}$$

$$\beta(f_{cm}) = \frac{5.3}{\sqrt{f_{cm}/f_{cm0}}}$$

$$\beta(t_0) = \frac{1}{0.1 + (t_0/t_1)^{0.2}}$$

$$\beta_c(t - t_0) = \left[\frac{(t - t_0)/t_1}{\beta_H + (t - t_0)/t_1}\right]^{0.3}$$

$$\beta_H = 150\left\{1 + \left(1.2\frac{RH}{RH_0}\right)^{18}\right\}.\frac{h}{h_0} + 250 \qquad < \; 1500$$

h_0 = 100 mm

f_{cm0} = 10 MPa

t_1 =1 day

RH_0 = 100%

Effect of type of cement and curing temperature

Modifying the age at loading

$$t_0 = t_{0,T} \cdot \left(\frac{9}{2 + \left(t_{0,T} / t_{1,T}\right)^{1.2}} + 1 \right)^{\alpha} \geq 0.5 \text{ days}$$

$$t_{0,T} = \sum_{i=1}^{n} \Delta t_i \exp\left[13.65 - \frac{4000}{273 + T(\Delta t_i)/T_0} \right]$$

$t_{0,T}$ is the temperature adjusted concrete age

Δt_i is the number of days where a temperature T prevails

$T(\Delta t_i)$ is the temperature (°C) during the time period Δt_i

$T_0 = 1^{o}$C

Type of cement	32.5	32.5R 42.5	42.5R 52.5
	slow hardening cement	normal and rapid hardening cement	rapid hardening high strength
α	-1	0	1

Effect of high stresses

With the rang of service stresses $0.4 f_{cm}(t_0) < |\sigma_c| < 0.6 f_{cm}(t_0)$

$$k_{\sigma} = |\sigma_c| / f_{cm}(t_0)$$

$$\phi_{0,k} = \phi_0 \exp[\alpha_{\sigma}(k_{\sigma} - 0.4)] \quad \text{for } 0.4 < k_{\sigma} < 0.6$$

$$\phi_{0,k} = \phi_0 \quad \text{for } k_{\sigma} < 0.4$$

$$\alpha_{\sigma} = 1.5$$

Effect of temperature

$\beta_{H,T} = \beta_H \beta_T$ replaces β_H in last equation

$$\beta_T = \exp[1500/(273 + T/T_0) - 5.12]$$

$$\phi_{RH,T} = \phi_T + (\phi_{RH} - 1)\phi_T^{1.2}$$

$$\phi_T = \exp[0.015(T/T_0 - 20)]$$

$$\phi(t,t_0,T) = \phi_0 \beta_c (t - t_0) + \Delta\phi_{T,trans}$$

$$\Delta\phi_{T,trans} = 0.0004(T/T_0 - 20)^2$$

Development of strength with time

$$f_{cm}(t) = \beta_{cc}(t) f_{cm}$$

$$\beta_{cc}(t) = \exp\left\{ s\left[1 - \left(\frac{28}{t/t_1}\right)^{1/2}\right]\right\}$$

t_1 = 1 day

Type of cement	32.5	32.5R 42.5	42.5R 52.5
	slow hardening cement	normal and rapid hardening cement	rapid hardening high strength
S	0.38	0.25	0.20

Effect of temperature

$$f_{cm}(T) = f_{cm}(1.06 - 0.003T/T_0)$$

f_{cm} is the compressive strength at 20°C

Strength under sustained loads

$$f_{cm,sus}(t,t_0) = f_{cm}\beta_{cc}(t)\beta_{c,sus}(t,t_0)$$

$$\beta_c(t,t_0) = 0.96 - 0.12\left\{\ln\left[72\left(\frac{t - t_0}{t_1}\right)\right]\right\}^{1/4}$$

Modulus of elasticity

$$E_{ci} = E_{co}\left[\left(f_{ck} + \Delta f\right)/ f_{cmo}\right]^{1/3}$$

$$\Delta f = 8 \text{ MPa}$$

$$f_{cmo} = 10 \text{ MPa}$$

$$E_{co} = 2.15 \times 10^4 \text{ MPa}$$

$$f_{cm} = f_{ck} + \Delta f$$

$$E_{ci} = E_{co}\left[f_{cm} / f_{cmo}\right]^{1/3}$$

$$E_c = 0.85E_{ci}$$

Effect of temperature

$$E_{ci}(T) = E_{ci}(1.06 - 0.003T / T_0)$$

Development of modulus of elasticity with time

$$E_{ci}(t) = \beta_E(t)E_{ci}$$

$$\beta_E(t) = \left[\beta_{cc}(t)\right]^{0.5}$$

3- ACI209 model

Calculate Compressive Strength:

$$f_c'(t_0) = f_c'(28)\frac{t_0}{b + ct_0}$$

where;

$f_c'(t_o)$ = compressive strength of concrete at age of concrete loading, t_o

Type of Cement	Moist Cured Concrete		Steam Cured Concrete	
I	b = 4.0	c = 0.85	b = 1.0	c = 0.95
III	b = 2.3	c =0.92	b = 0.7	c = 0.98

Note: The experimental $f_c'(t_o)$ was used for the calculations to obtain a more accurate value.

Calculate Modulus of Elasticity:

$$E_{cmt0} = 33\gamma^{3/2}(f_c'(t_0))^{1/2}$$

Note: The experimental E_{cmto} was used when calculating the compliance function to obtain a more accurate value.

Calculate Shrinkage Strain:

$$\varepsilon_s(t_s) = \frac{t_s}{b + t_s}K_{SS}K_{SH}\varepsilon_{shu}$$

K_{SS} = 1.14 – 0.09(V/S)

$\varepsilon_{shu} = 780x10^{-6}$ in/in

Humidity	Moist Cured Concrete	Steam Cured Concrete
40 % $\leq$H $\leq$80 %	b = 35 t $\geq$7 days K_{SH} = 1.4 – 0.01H	b = 55 t$\geq$1 to 3 days K_{SH} = 1.4 – 0.01H
80 % $\leq$H $\leq$100 %	b = 35 t $\geq$7 days K_{SH} = 3 – 0.03H	b = 55 t $\geq$1 to 3 days K_{SH} = 3 – 0.03H

Calculate Creep Strain:

$$\varepsilon_{cc}(t) = \frac{\sigma}{E_{cmt0}} C_c(t)$$

Where $C_c(t) = \dfrac{t^{0.6}}{10 + t^{0.6}} C_{cu} K_{CH} K_{CA} K_{CS}$

and

C_{cu} = 2.35

K_{CH} = 1.27 – 0.0067H

K_{CS} = 1.14 – 0.09(V/S)

Moist Cured Concrete	Steam Cured Concrete
t, $t_o$$\geq$7 days, H $\geq$40 % K_{CA} = 1.25 $(t_o)^{-0.118}$	t, t_o $\geq$1 to 3 days, H $\geq$40 % K_{CA} = 1.13 $(t_o)^{-0.095}$

Calculate Creep Compliance Function:

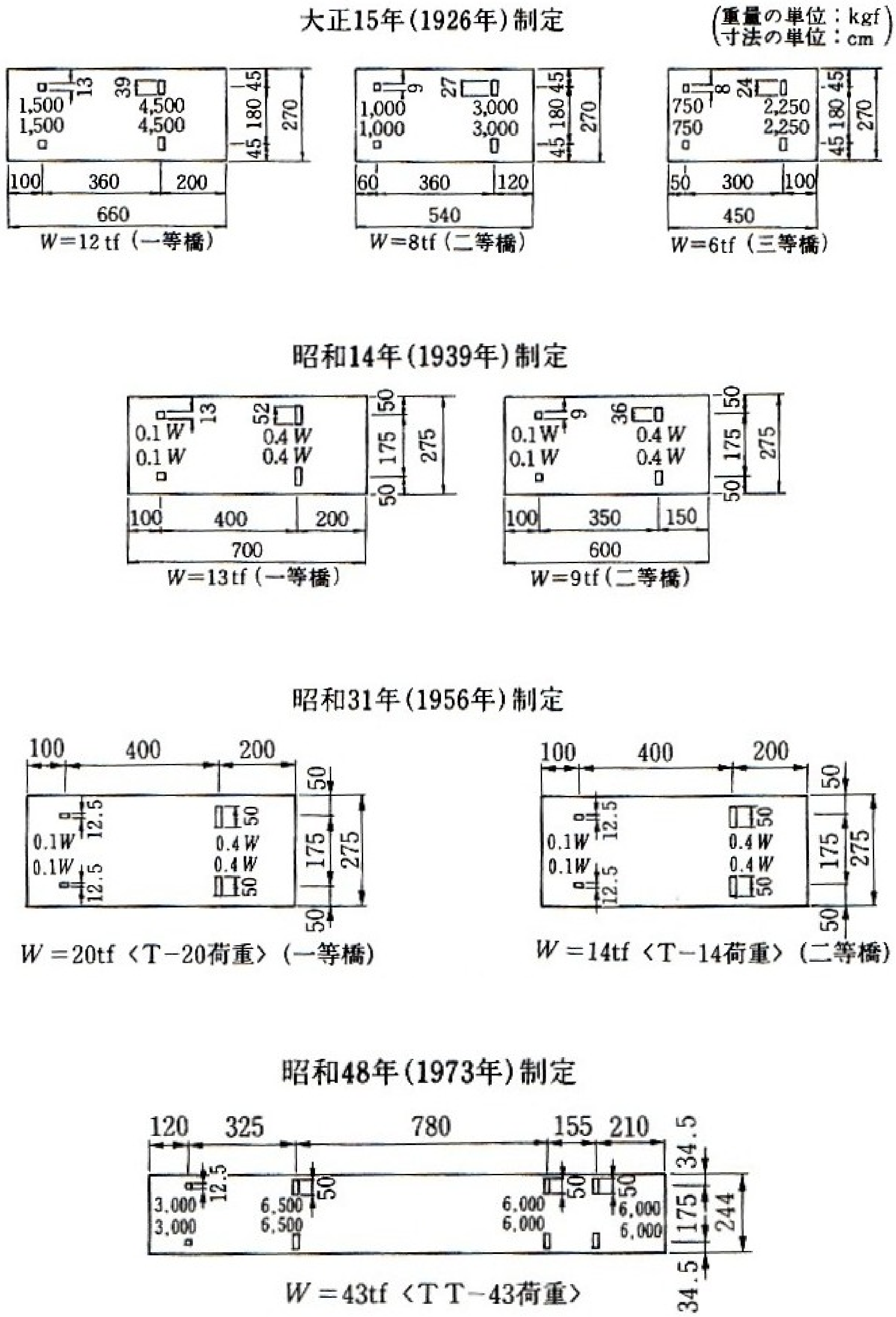
$$J(t,0) = \frac{1 + C_c(t)}{E_{cmt0}} \quad \mu / psi$$

Calculate Total Strain:

$$\varepsilon(t) = \varepsilon_s(t) + \frac{\sigma}{E_{cmt0}}(1 + C_c(t))$$

Annex 2: Traffic load model

The change in time of model vehicles used in Japanese for traffic load model in bridge design:



T load

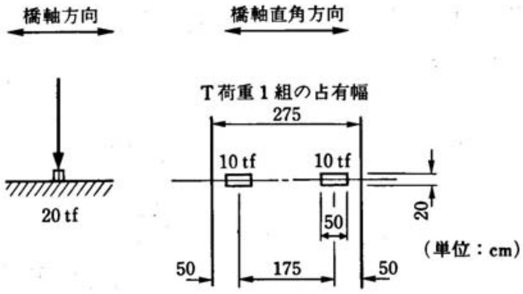
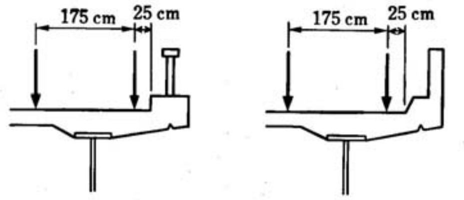
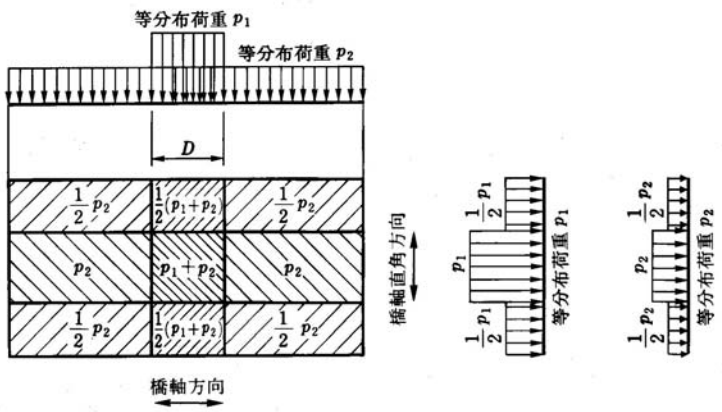


図 2.2 T荷重

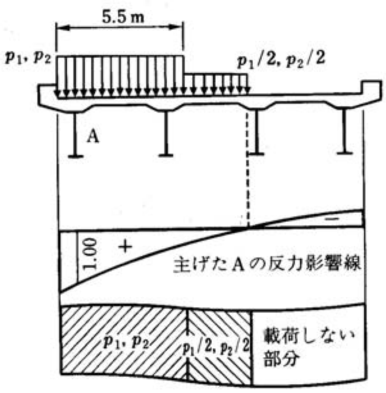


T荷重の載荷位置

L load



L荷重



けたAの反力の影響線と
L荷重の載荷方法

Values of uniform load p1 and p2

L荷重（B活荷重）

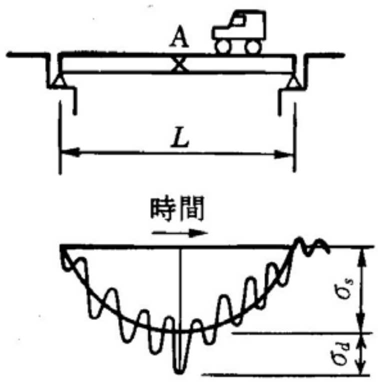
主載荷荷重（幅5.5 m）						従載荷荷重
	等分布荷重 p_1		等分布荷重 p_2			
載荷長 D(m)	荷　重（kgf/m²）		荷　重（kgf/m²）			
	曲げモーメントを算出する場合	せん断力を算出する場合	$L\leq 80$	$80<L\leq 130$	$L>130$	
10	1,000	1,200	350	$430-L$	300	主載荷荷重の50%

L：支間長（m）

For the case of A load type, D=7m

Impact load coefficient

$$i=\frac{20}{50+L}$$

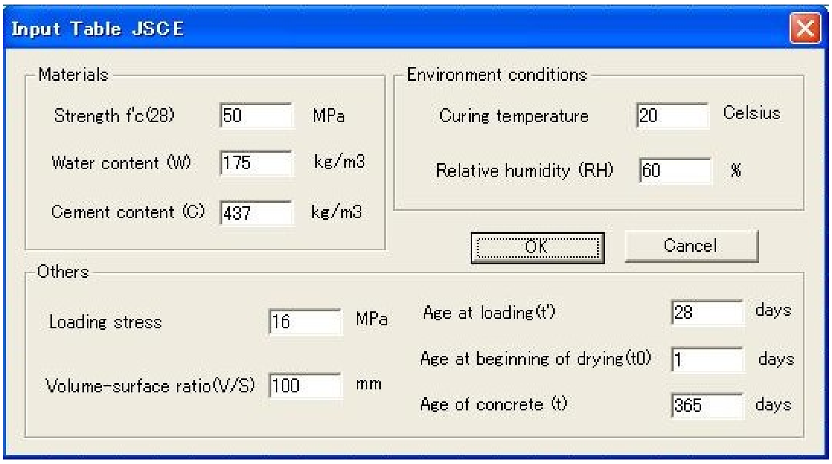


A点の動的応答曲線

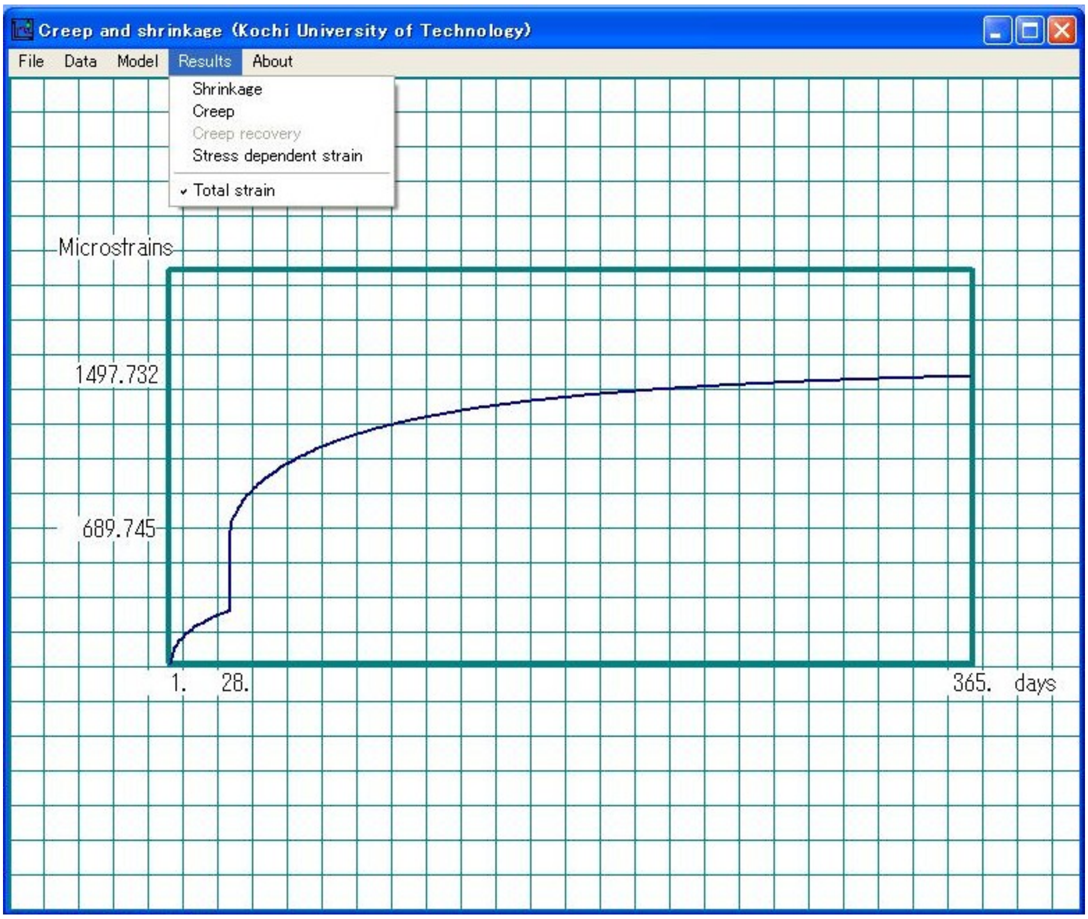
Annex 3: Computer program

Three models (JSCE2000, CEB-FIP90 and ACI209) of creep and shrinkage were implemented in a program named creep.

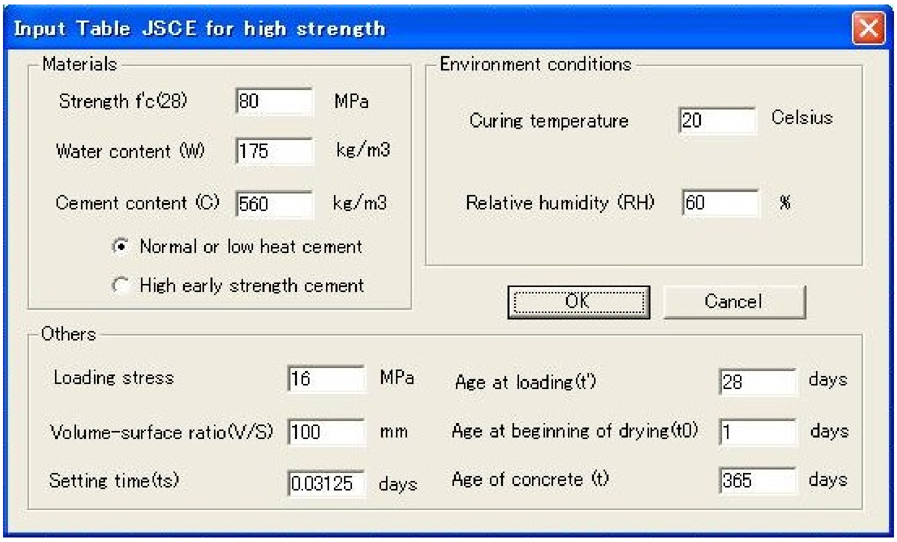
Input table for JSCE model



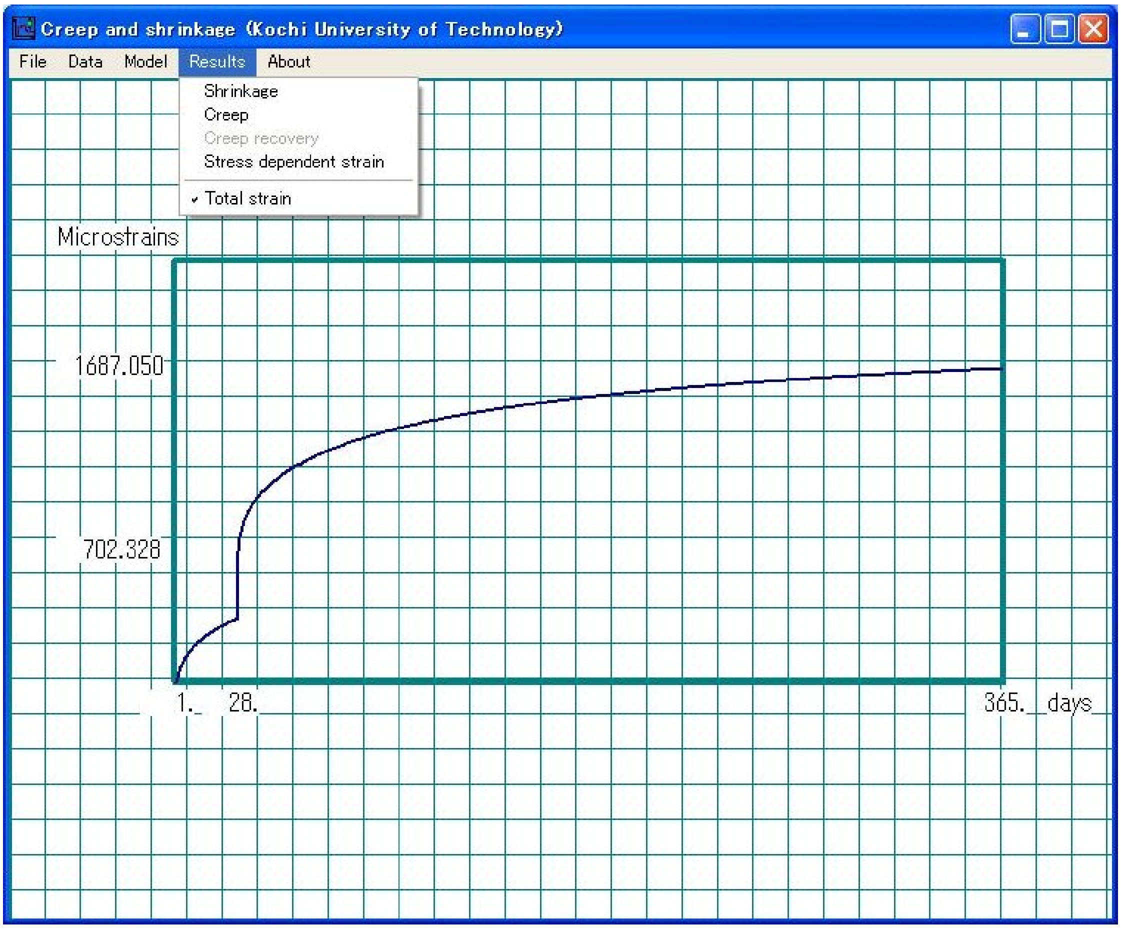
Total strain up to 365 days



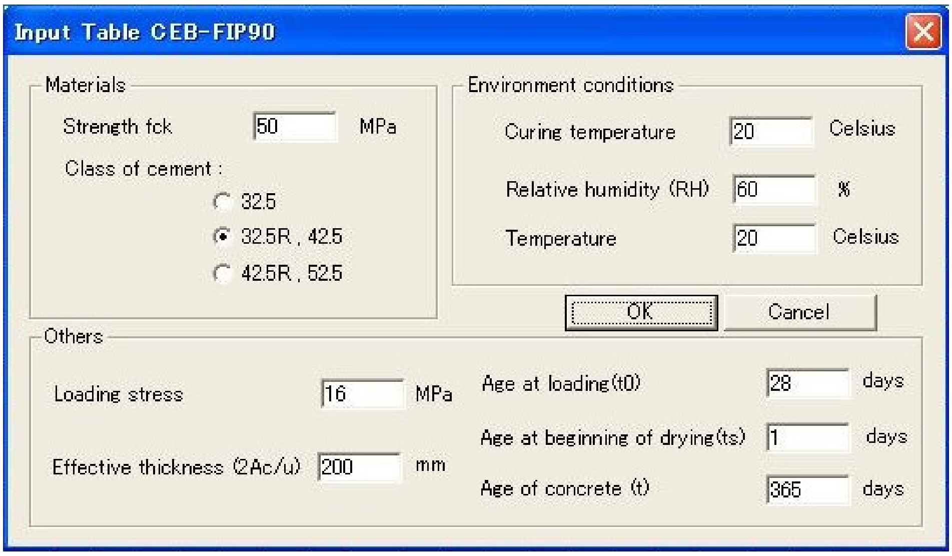
Input table for JSCE model for high strength concrete



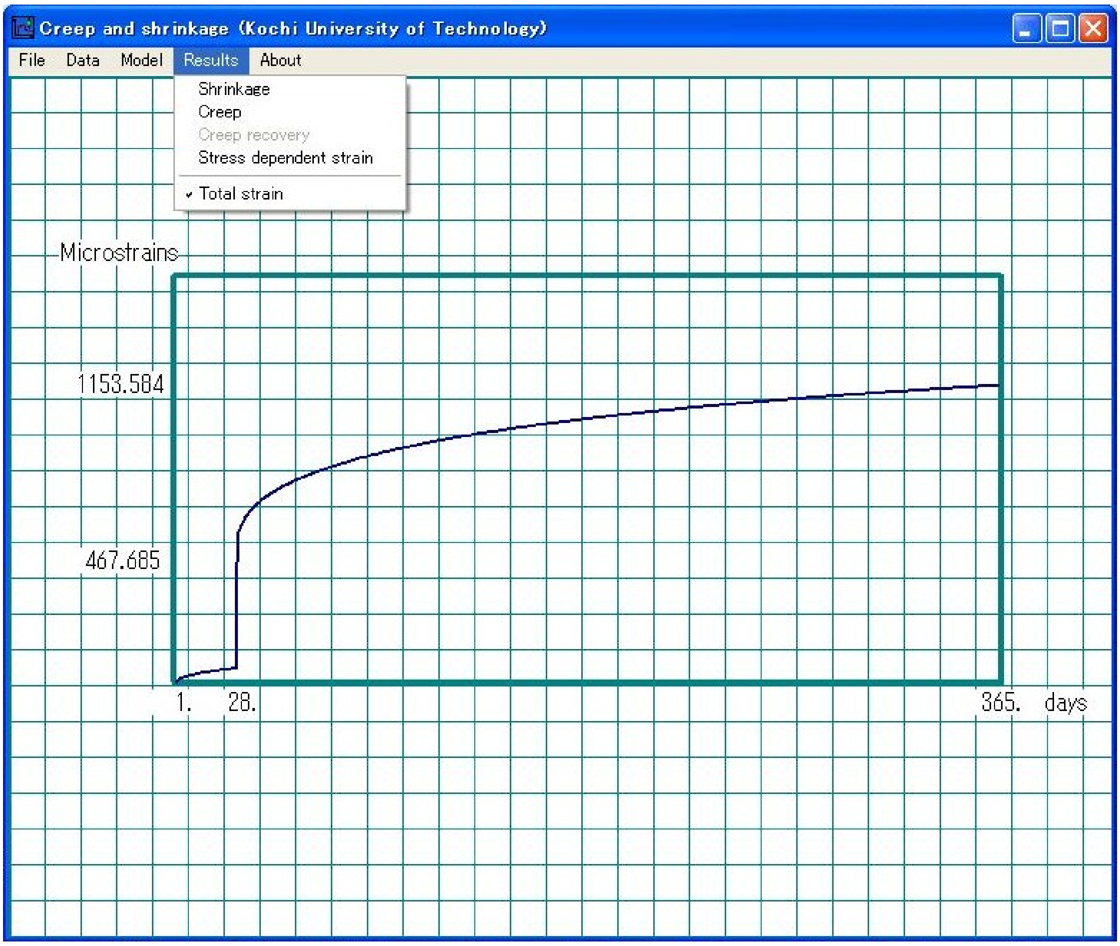
Total strain up to 365 days



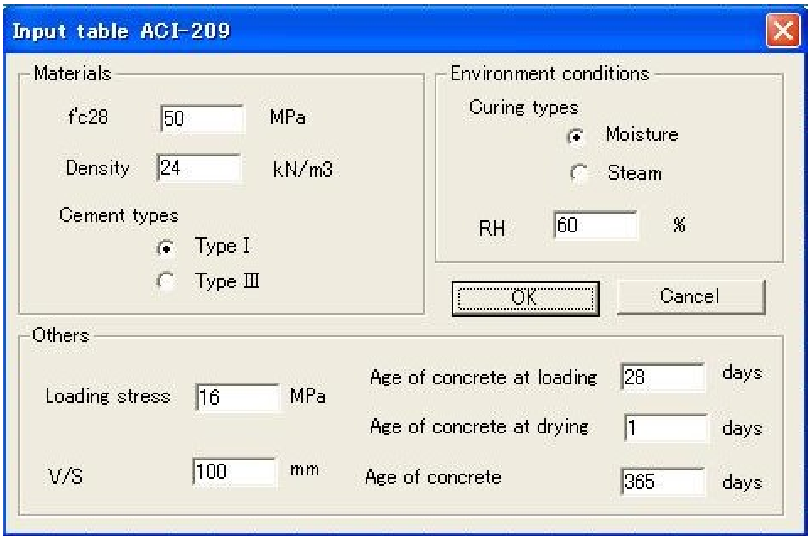
Input table for CEB-FIP90 model



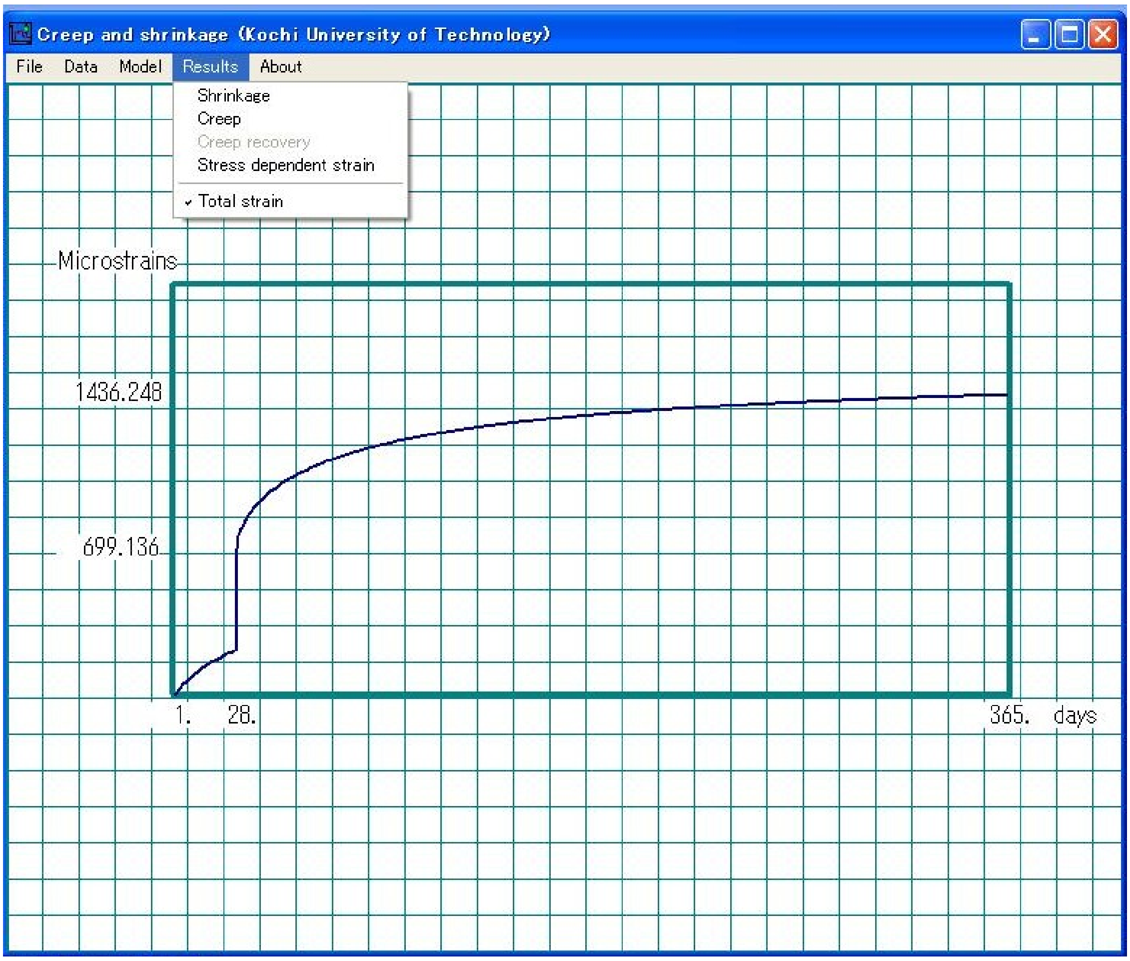
Total strain up to 365 days



Input table for ACI209 model

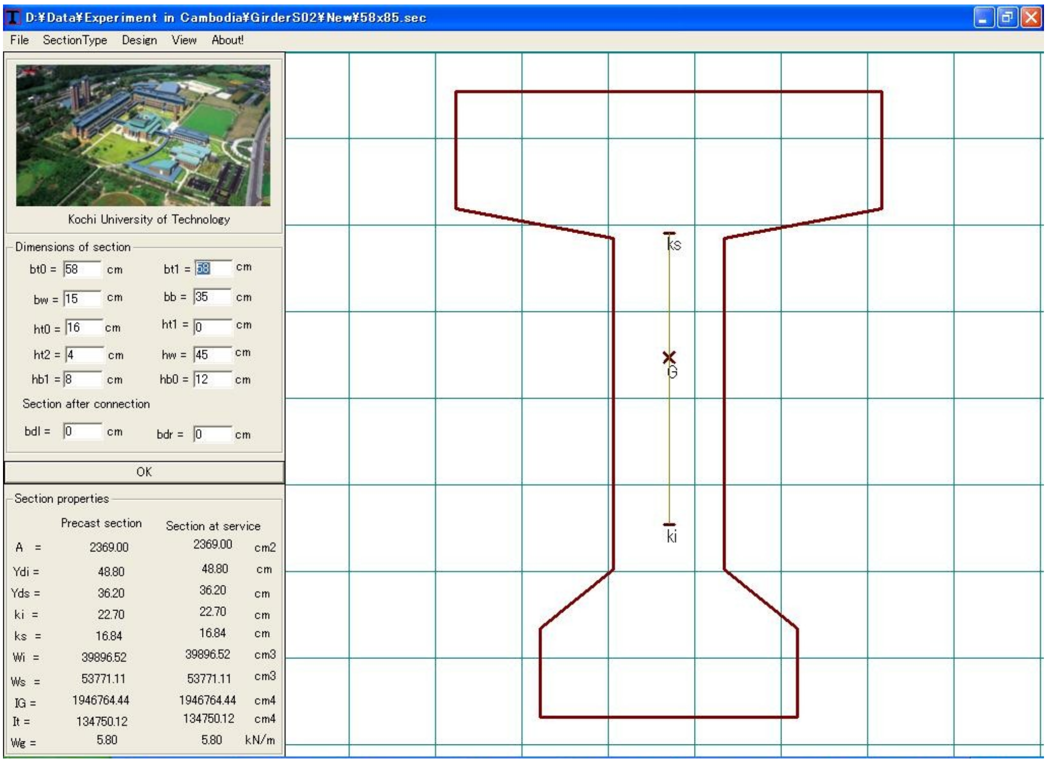


Total strain up to 365 days

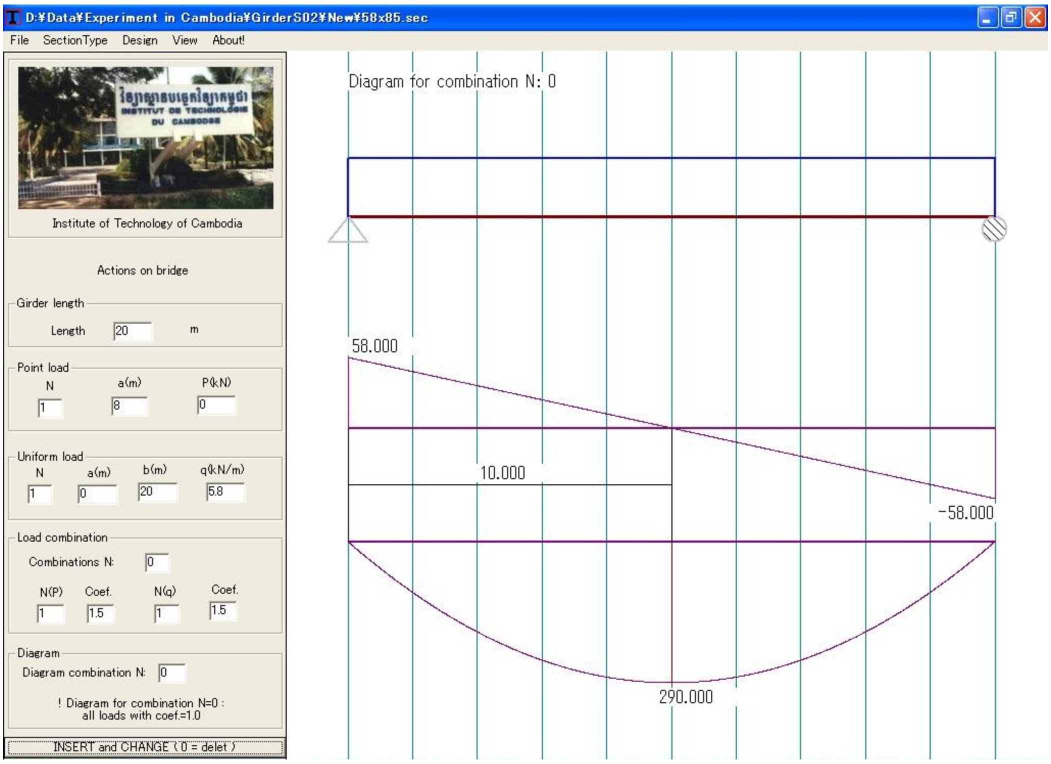


PC girder design is implemented in a program named ‘Section’.

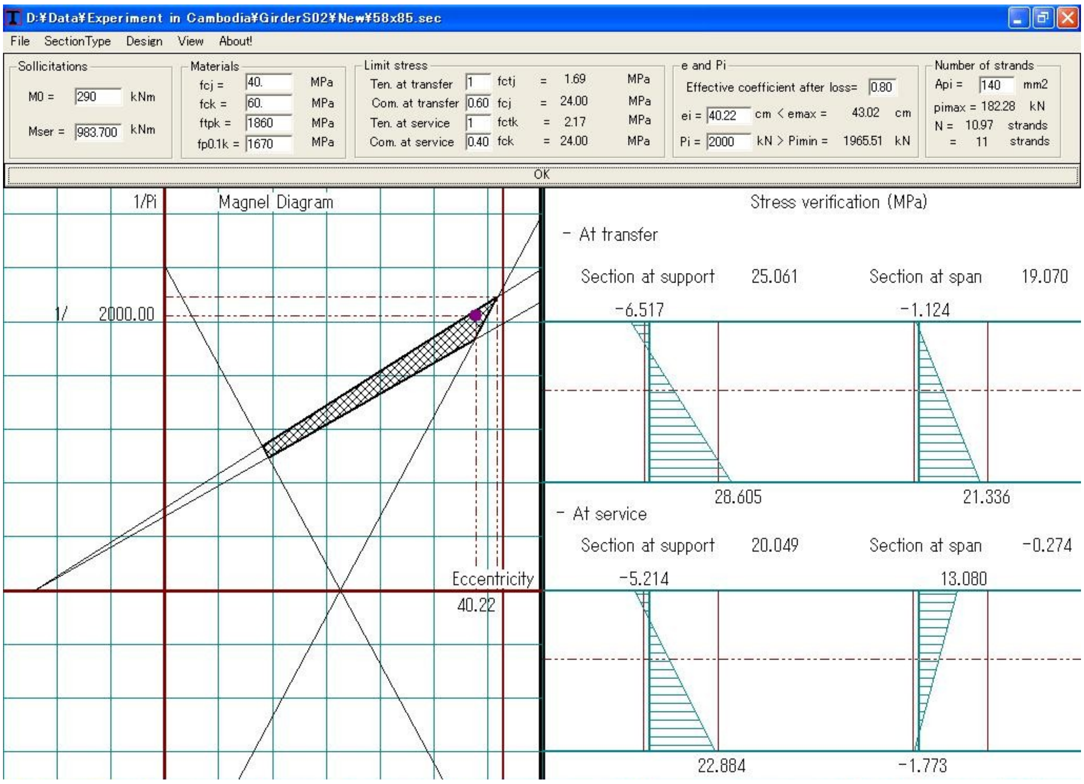
Section properties of girder



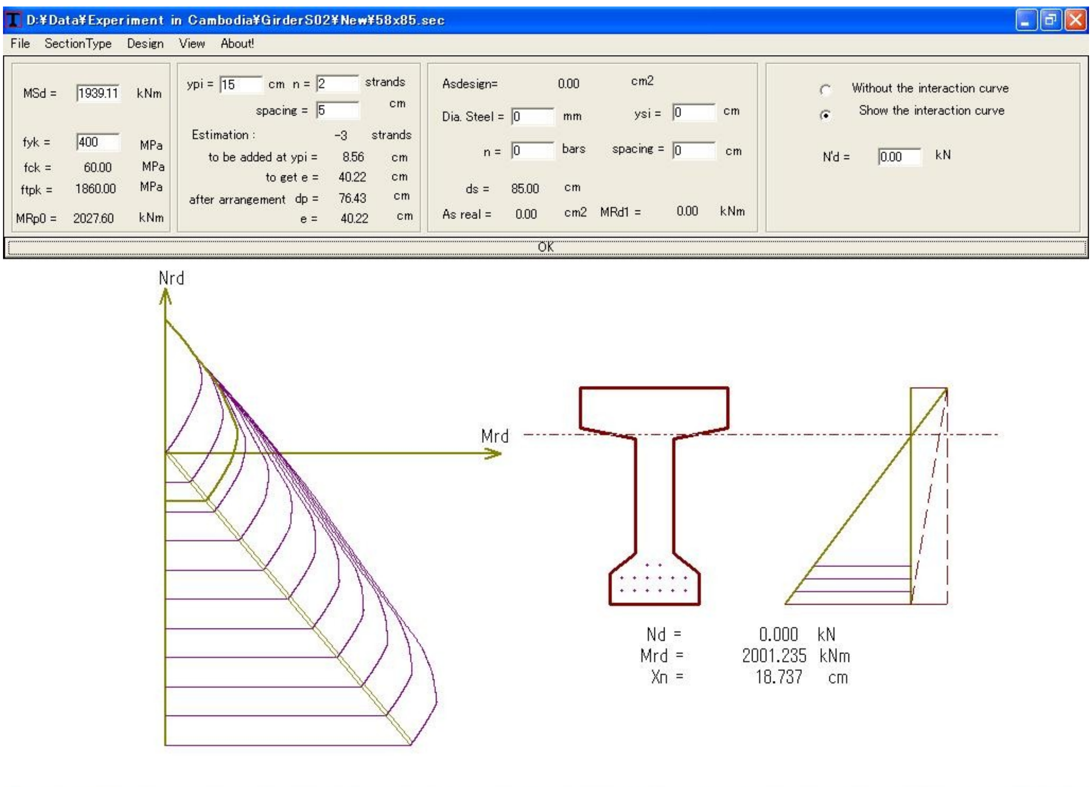
Free body diagram for simple case



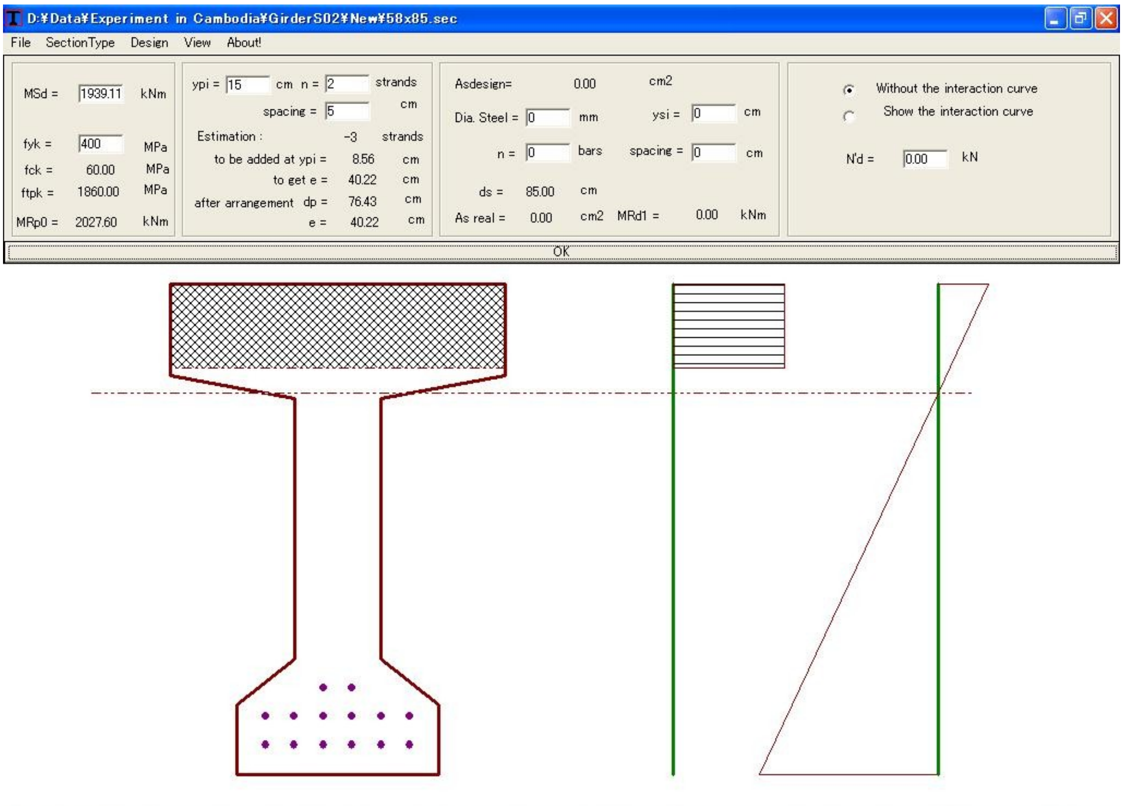
Determination of prestressing force and its eccentricity



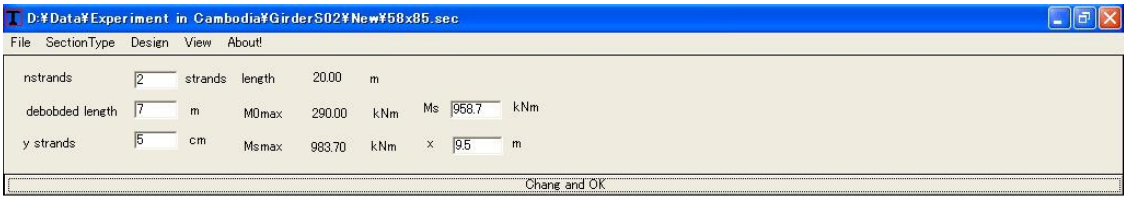
Ultimate limit states design and verification



Ultimate limit states design and verification

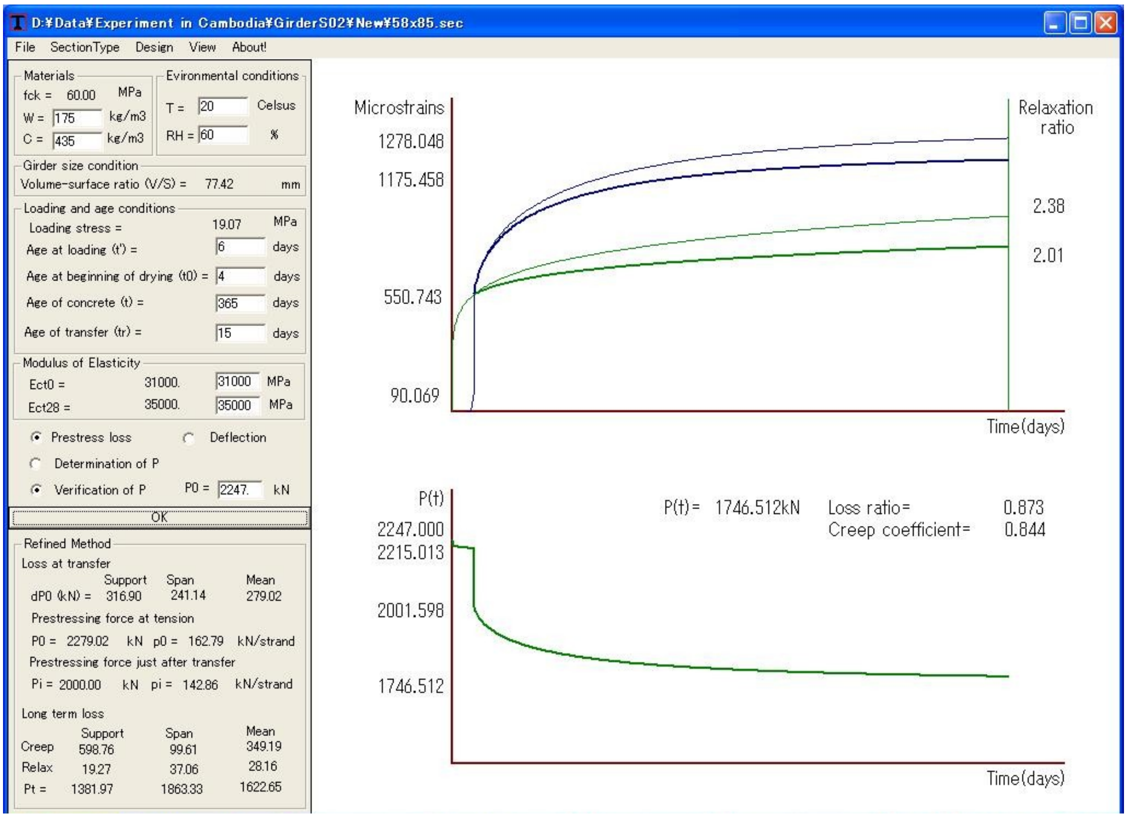


Bond control verification

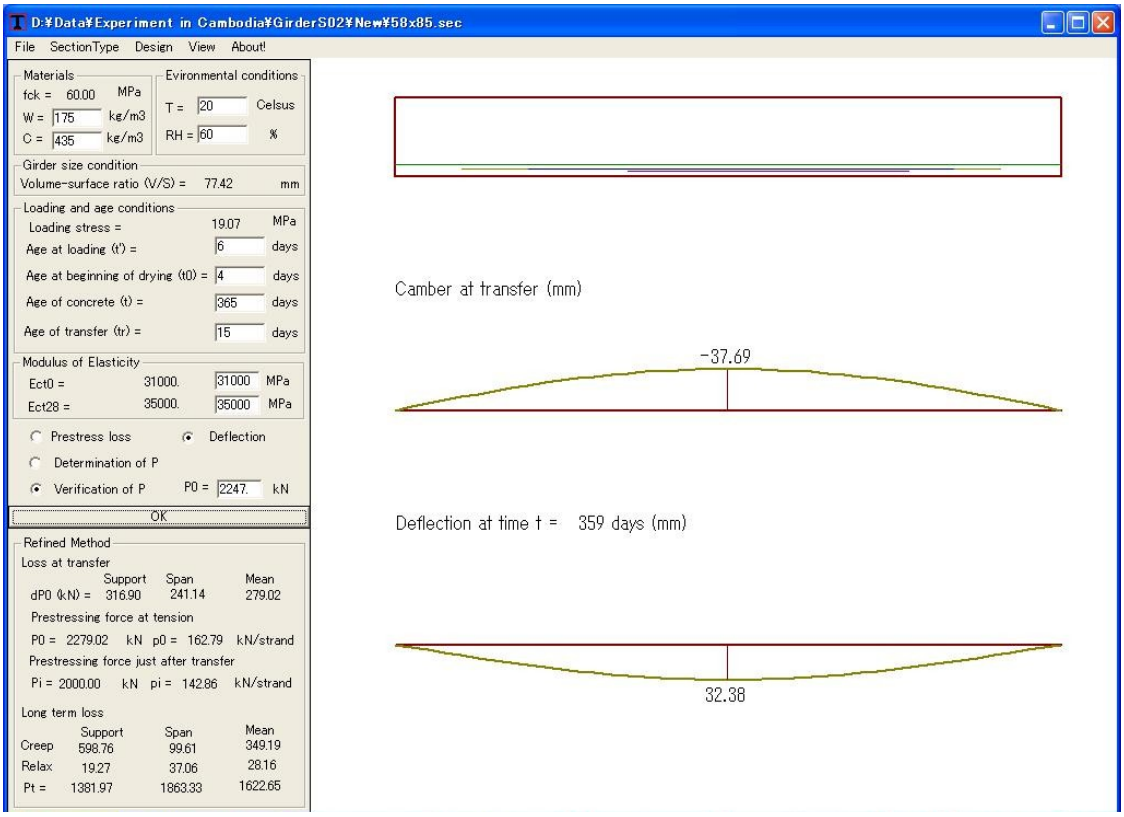


x	bonded	P	e0	es	M0	Ms	S0i	S0s	Sti	Sts
0.00	4.	571.43	36.30	36.30	0.00	0.00	7.61	−1.45	6.09	−1.16
0.50	4.	571.43	36.30	36.30	28.27	73.30	6.90	−0.92	4.25	0.21
1.00	4.	571.43	36.30	36.30	55.10	144.10	6.23	−0.42	2.48	1.52
1.50	4.	571.43	36.30	36.30	80.47	212.30	5.59	0.05	0.77	2.79
2.00−	4.	571.43	36.30	36.30	104.40	278.00	4.99	0.50	−0.88	4.01
2.00+	8.	1142.86	38.80	38.80	104.40	278.00	13.32	−1.48	5.78	2.43
2.50	8.	1142.86	38.80	38.80	126.88	341.20	12.76	−1.06	4.20	3.61
3.00	8.	1142.86	38.80	38.80	147.90	401.80	12.23	−0.67	2.68	4.74
3.50	8.	1142.86	38.80	38.80	167.48	459.90	11.74	−0.31	1.22	5.82
4.00−	8.	1142.86	38.80	38.80	185.60	515.40	11.29	0.03	−0.17	6.85
4.00+	12.	1714.29	39.63	39.63	185.60	515.40	19.61	−1.95	6.49	5.27
4.50	12.	1714.29	39.63	39.63	202.27	568.40	19.19	−1.64	5.16	6.25
5.00	12.	1714.29	39.63	39.63	217.50	618.90	18.81	−1.35	3.90	7.19
5.50	12.	1714.29	39.63	39.63	231.27	666.80	18.47	−1.10	2.70	8.08
6.00	12.	1714.29	39.63	39.63	243.60	712.20	18.16	−0.87	1.56	8.93
6.50	12.	1714.29	39.63	39.63	254.48	755.00	17.89	−0.67	0.49	9.72
7.00−	12.	1714.29	39.63	39.63	263.90	795.30	17.65	−0.49	−0.52	10.47
7.00+	14.	2000.00	40.22	40.22	263.90	795.30	21.99	−1.61	2.95	9.58
7.50	14.	2000.00	40.22	40.22	271.88	833.10	21.79	−1.46	2.00	10.28
8.00	14.	2000.00	40.22	40.22	278.40	868.30	21.63	−1.34	1.12	10.93
8.50	14.	2000.00	40.22	40.22	283.48	900.90	21.50	−1.25	0.30	11.54
9.00	14.	2000.00	40.22	40.22	287.10	931.10	21.41	−1.18	−0.45	12.10
9.50	14.	2000.00	40.22	40.22	289.27	958.70	21.36	−1.14	−1.14	12.61
10.00	14.	2000.00	40.22	40.22	290.00	983.70	21.34	−1.13	−1.77	13.08

Prestress loss



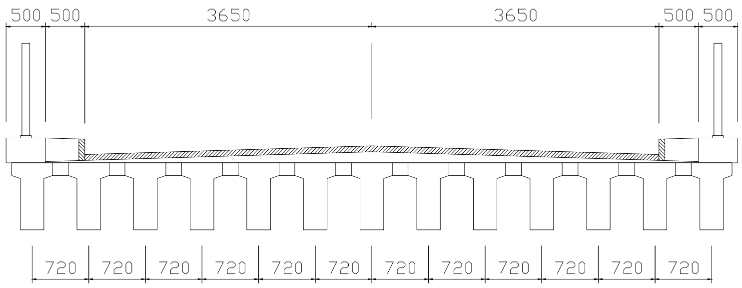
Camber and deflection

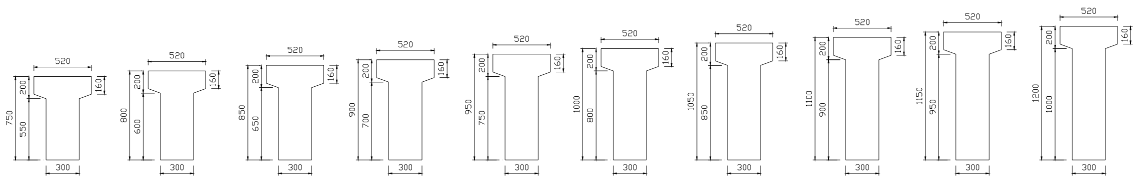


Annex 4: Calculation Table

Notation

h	Girder height
A	Girder section area
Self-weight	Self-weight of girder
I	Inertia of girder section
Wi	Lower part of section modulus
Ws	Upper part of section modulus
M self	Bending moment due to self-weight
Mdesign	Bending moment due to service load
Msdu	Bending moment due to ultimate load
Pi	Initial prestressing force just after transfer
e	Eccentricity of prestressing force
Ap	Total section area of prestressing steel
n	Number of prestressing steel
σpi	Initial prestress just after transfer
σ limits	Stress limit (compressive and tensile at transfer and at service)
σ at support	Stress at support
σ at span	Stress at span
Debonded	Debonded length and number of debonded strands
σ at support	Stress at support after debonded strands
σ at X1	Stress at debonded location
Mcr	Cracking bending moment
Mu	Ultimate bending moment
Cost/girder	Cost of concrete and PC strands per girder
Cost	Cost of concrete and PC strands

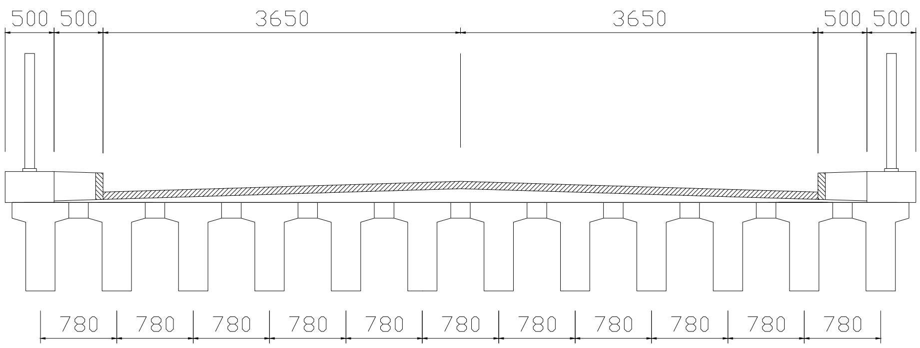


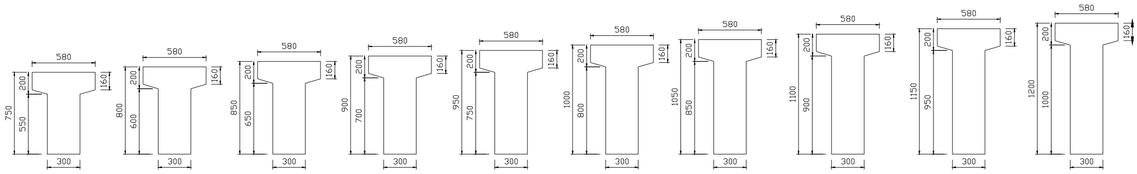


#	unit	G13 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2646		2796		2946		3096		3246		3396		3546		3696		3846		3996	
Self-weight	ton	13.414		14.180		14.945		15.711		16.457		17.222		17.988		18.754		19.499		20.265	
I	cm^4	1338445		1616833		1930091		2280107		2668765		3097947		3569534		4085408		4647448		5257533	
Wi	cm^3	32051		36427		41067		45970		51133		56556		62237		68176		74371		80822	
Ws	cm^3	40266		45398		50789		56438		62343		68503		74917		81585		88506		95679	
M self	kNm	324.0		342.5		361.0		379.5		397.5		416.0		434.5		453.0		471.0		489.5	
Mdesign	kNm	964.3		983.7		1003.0		1022.4		1041.8		1061.1		1080.4		1099.7		1119.0		1138.3	
Msdu	kNm	1860.4		1885.4		1910.3		1935.3		1960.2		1985.1		2009.9		2034.7		2059.4		2084.1	
Pi	kN			2450		2248		2100		1980		1890		1795		1725		1645		1585	
e	cm			33.14		37.00		40.37		43.44		46.03		49.17		51.74		54.99		57.55	
Ap	mm^2			2240		2100		1820		1680		1680		1540		1540		1400		1400	
n	Strands			16		15		13		12		12		11		11		10		10	
σpi	MPa			1094		1070		1154		1179		1125		1166		1120		1175		1132	
	%			65		64		69		71		67		70		67		70		68	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa			-9.12	-7.30	-8.75	-7.00	-8.24	-6.59	-7.70	-6.16	-7.13	-5.71	-6.72	-5.38	-6.27	-5.02	-5.94	-4.75	-5.57	-4.45
				31.05	24.84	27.88	22.31	25.22	20.18	22.92	18.34	20.95	16.76	19.24	15.39	17.76	14.21	16.44	13.15	15.25	12.20
σ at span	MPa			-1.58	14.37	-1.64	12.75	-1.51	11.52	-1.32	10.55	-1.06	9.78	-0.92	9.05	-0.72	8.46	-0.62	7.89	-0.45	7.44
				21.65	-2.16	19.09	-2.12	16.97	-2.06	15.15	-2.04	13.59	-2.00	12.26	-1.97	11.11	-1.92	10.11	-1.89	9.20	-1.88
Debonded	Strands			13		13		11		10		10		9		9		8		8	
	X1(m)			9.0		9.5		9.0		8.0		7.5		7.0		6.5		6.0		5.5	
σ at support	MPa			-1.71		-1.17		-1.27		-1.28		-1.19		-1.22		-1.14		-1.19		-1.11	
				5.82		3.72		3.88		3.82		3.49		3.50		3.23		3.29		3.05	
σ at X1	MPa			-1.65		-1.66		-1.58		-1.58		-1.44		-1.44		-1.40		-1.47		-1.49	
				21.74		19.12		17.05		15.46		14.05		12.89		11.93		11.12		10.42	
Mcr	kNm			985.4		1005.1		1025.5		1044.7		1064.3		1084.5		1105.1		1125.1		1143.8	
Mu	kNm			1898.4		2012.6		1981.9		1993.2		2119.0		2084.4		2199.7		2131.1		2236.0	
Cost/girder	USD			645.1		640.9		614.8		609.1		624.8		619.7		635.4		630.2		645.9	
Cost	USD			9789.8		9813.5		9162.7		8854.8		9000.4		8783.6		8935.7		8738.3		8896.9	

#	unit	G13 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2646		2796		2946		3096		3246		3396		3546		3696		3846		3996	
Self-weight	ton	13.414		14.180		14.945		15.711		16.457		17.222		17.988		18.754		19.499		20.265	
I	cm^4	1338445		1616833		1930091		2280107		2668765		3097947		3569534		4085408		4647448		5257533	
Wi	cm^3	32051		36427		41067		45970		51133		56556		62237		68176		74371		80822	
Ws	cm^3	40266		45398		50789		56438		62343		68503		74917		81585		88506		95679	
M self	kNm	324.0		342.5		361.0		379.5		397.5		416.0		434.5		453.0		471.0		489.5	
Mdesign	kNm	964.3		983.7		1003.0		1022.4		1041.8		1061.1		1080.4		1099.7		1119.0		1138.3	
Msdu	kNm	1860.4		1885.4		1910.3		1935.3		1960.2		1985.1		2009.9		2034.7		2059.4		2084.1	
Pi	kN							2290		2140		1940		1860		1790		1710		1650	
e	cm							37.10		40.76		46.03		49.17		51.74		54.99		57.55	
Ap	mm^2							2240		1960		1680		1540		1540		1400		1400	
n	strands							16		14		12		11		11		10		10	
σpi	MPa							1022		1092		1155		1208		1162		1221		1179	
	%							61		65		69		72		70		73		71	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa							-7.66	-6.13	-7.40	-5.92	-7.32	-5.86	-6.96	-5.57	-6.51	-5.21	-6.18	-4.94	-5.80	-4.64
								25.88	20.70	23.65	18.92	21.50	17.20	19.94	15.95	18.43	14.74	17.09	13.67	15.88	12.70
σ at span	MPa							-0.93	11.99	-1.02	10.79	-1.25	9.63	-1.16	8.85	-0.96	8.27	-0.86	7.70	-0.68	7.26
								17.62	-1.54	15.88	-1.45	14.15	-1.56	12.96	-1.41	11.78	-1.39	10.76	-1.37	9.82	-1.38
Debonded	strands							14		12		10		9		9		8		8	
	X1(m)							8.0		8.0		9.0		8.5		8.0		7.5		7.0	
σ at support	MPa							-0.96		-1.06		-1.22		-1.27		-1.18		-1.24		-1.16	
								3.23		3.38		3.58		3.63		3.35		3.42		3.18	
σ at X1	MPa							-1.20		-1.28		-1.31		-1.29		-1.18		-1.19		-1.14	
								17.95		16.19		14.22		13.12		12.05		11.15		10.37	
Mcr	kNm							1027.8		1050.7		1063.4		1090.9		1111.0		1130.7		1148.8	
Mu	kNm							1963.2		1985.5		1996.1		2016.4		2132.7		2076.2		2181.0	
Cost/girder	USD							651.7		624.9		599.2		592.8		607.3		600.9		615.4	
Cost	USD							9824.0		9268.1		8842.2		8590.3		8726.8		8494.3		8637.3	

#	unit	G13 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2646	2796	2946	3096	3246	3396	3546	3696	3846	3996
Self-weight	ton	13.414	14.180	14.945	15.711	16.457	17.222	17.988	18.754	19.499	20.265
I	cm^4	1338445	1616833	1930091	2280107	2668765	3097947	3569534	4085408	4647448	5257533
Wi	cm^3	32051	36427	41067	45970	51133	56556	62237	68176	74371	80822
Ws	cm^3	40266	45398	50789	56438	62343	68503	74917	81585	88506	95679
M self	kNm	324.0	342.5	361.0	379.5	397.5	416.0	434.5	453.0	471.0	489.5
Mdesign	kNm	964.3	983.7	1003.0	1022.4	1041.8	1061.1	1080.4	1099.7	1119.0	1138.3
Msdu	kNm	1860.4	1885.4	1910.3	1935.3	1960.2	1985.1	2009.9	2034.7	2059.4	2084.1
Pi	kN	2850	2360	2210	2100	1960	1850	1770	1680	1615	1555
e	cm	27.26	34.39	37.36	40.37	43.44	46.59	49.17	52.42	54.99	57.55
Ap	mm^2	2660	2100	1960	1820	1680	1540	1540	1400	1400	1400
n	strands	19	15	14	13	12	11	11	10	10	10
σpi	MPa	1071	1124	1128	1154	1167	1201	1149	1200	1154	1111
	%	64	67	68	69	70	72	69	72	69	67
σ limits	MPa	2.26 / 2.71	2.21 / 2.65	2.17 / 2.6	2.13 / 2.56	2.09 / 2.52	2.06 / 2.48	2.03 / 2.44	2 / 2.41	1.98 / 2.38	1.95 / 2.35
		36 / 32	36 / 32	36 / 32	36 / 32	36 / 32	36 / 32	36 / 32	36 / 32	36 / 32	36 / 32
σ at support	MPa	-8.52 / -6.82	-9.44 / -7.55	-8.75 / -7.00	-8.24 / -6.59	-7.62 / -6.10	-7.13 / -5.71	-6.63 / -5.30	-6.25 / -5.00	-5.84 / -4.67	-5.46 / -4.37
		35.01 / 28.01	30.72 / 24.58	27.61 / 22.09	25.22 / 20.18	22.69 / 18.15	20.69 / 16.55	18.98 / 15.18	17.46 / 13.97	16.14 / 12.91	14.96 / 11.97
σ at span	MPa	-0.48 / 17.13	-1.89 / 14.12	-1.65 / 12.75	-1.51 / 11.52	-1.24 / 10.61	-1.06 / 9.78	-0.83 / 9.12	-0.70 / 8.48	-0.51 / 7.98	-0.35 / 7.53
		24.90 / -2.08	21.32 / -2.43	18.82 / -2.34	16.97 / -2.06	14.92 / -2.22	13.33 / -2.21	11.99 / -2.18	10.82 / -2.16	9.81 / -2.13	8.91 / -2.11
Debonded	strands	14	12	11	10	9	8	8	7	7	7
	X1(m)	5.5	8.0	7.5	7.0	6.5	6.0	5.5	5.5	5.0	4.5
σ at support	MPa	-2.24	-1.89	-1.88	-1.90	-1.90	-1.95	-1.81	-1.87	-1.75	-1.64
		9.21	6.14	5.92	5.82	5.67	5.64	5.18	5.24	4.84	4.49
σ at X1	MPa	-2.11	-2.19	-2.09	-2.12	-2.02	-2.03	-2.00	-1.82	-1.84	-1.89
		26.95	21.69	19.37	17.71	15.87	14.51	13.41	12.16	11.39	10.74
Mcr	kNm	984.5	991.9	1014.0	1045.3	1056.9	1076.2	1096.8	1116.7	1137.2	1157.4
Mu	kNm	1905.3	1895.0	1960.8	2011.7	2026.3	1997.4	2112.7	2049.7	2154.6	2259.4
Cost/girder	USD	719.8	656.7	653.4	650.0	646.6	643.2	660.7	657.8	675.3	692.8
Cost	USD	10286.4	9681.6	9468.6	9268.6	9081.7	8907.7	9089.7	8980.8	9169.3	9357.8

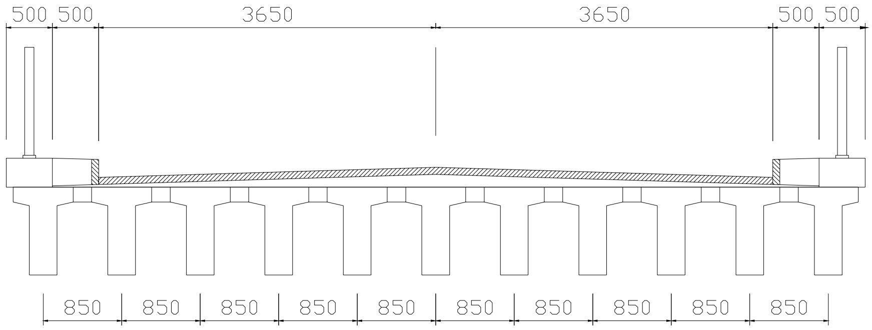


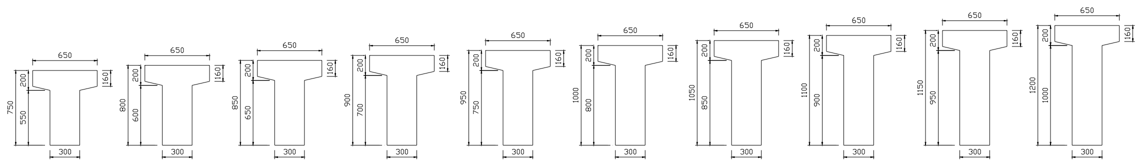


#	unit	G12 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2754		2904		3054		3204		3354		3504		3654		3804		3954		4104	
Self-weight	ton	13.973		14.718		15.484		16.250		17.015		17.761		18.527		19.292		20.058		20.804	
I	cm^4	1402218		1693272		2020483		2385747		2790955		3237996		3728756		4265120		4848970		5482190	
Wi	cm^3	32832		37318		42074		47096		52383		57933		63745		69817		76149		82739	
Ws	cm^3	43424		48901		54641		60640		66897		73411		80180		87203		94480		102011	
M self	kNm	337.5		355.5		374.0		392.5		411.0		429.0		447.5		466.0		484.5		502.5	
Mdesign	kNm	1035.0		1054.5		1074.0		1093.4		1112.9		1132.3		1151.7		1171.1		1190.5		1209.9	
Msdu	kNm	2007.0		2032.1		2057.2		2082.2		2107.2		2132.2		2157.1		2182.0		2206.8		2231.6	
Pi	kN			2648		2435		2230		2110		2000		1920		1820		1750		1670	
e	cm			33.15		36.77		41.01		44.05		47.14		49.74		52.91		55.50		58.76	
Ap	mm^2			2520		2240		1960		1820		1680		1680		1540		1540		1400	
n	strands			18		16		14		13		12		12		11		11		10	
σpi	MPa			1051		1087		1138		1159		1190		1143		1182		1136		1193	
	%			63		65		68		69		71		68		71		68		71	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa			-8.83	-7.07	-8.41	-6.73	-8.12	-6.50	-7.60	-6.08	-7.14	-5.71	-6.66	-5.33	-6.26	-5.01	-5.85	-4.68	-5.55	-4.44
				32.64	26.11	29.25	23.40	26.38	21.10	24.03	19.23	21.98	17.59	20.24	16.19	18.58	14.86	17.18	13.74	15.93	12.74
σ at span	MPa			-1.56	14.50	-1.57	12.92	-1.65	11.53	-1.46	10.55	-1.29	9.72	-1.08	9.04	-0.91	8.42	-0.73	7.92	-0.62	7.42
				23.11	-2.14	20.36	-2.12	18.04	-2.11	16.19	-2.02	14.58	-1.96	13.22	-1.88	11.90	-1.91	10.82	-1.89	9.86	-1.88
Debonded	strands			15		13		12		11		10		10		9		9		8	
	X1(m)			9.0		9.0		10.0		8.5		8.0		7.0		7.0		6.5		6.0	
σ at support	MPa			-1.47		-1.58		-1.16		-1.17		-1.19		-1.11		-1.14		-1.06		-1.11	
				5.44		5.49		3.77		3.70		3.66		3.37		3.38		3.12		3.19	
σ at X1	MPa			-1.64		-1.64		-1.65		-1.60		-1.52		-1.58		-1.40		-1.35		-1.41	
				23.21		20.45		18.04		16.36		14.87		13.85		12.50		11.60		10.83	
Mcr	kNm			1056.9		1075.8		1094.1		1116.9		1138.2		1161.4		1177.4		1197.0		1215.8	
Mu	kNm			2089.7		2127.9		2134.0		2151.7		2137.3		2263.1		2215.1		2330.4		2248.7	
Cost/girder	USD			698.5		672.9		648.4		642.2		637.0		652.2		647.5		663.2		658.0	
Cost	USD			9893.9		9371.1		9100.4		8726.2		8508.0		8582.4		8442.3		8582.7		8400.5	

#	unit	G12 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2754		2904		3054		3204		3354		3504		3654		3804		3954		4104	
Self-weight	ton	13.973		14.718		15.484		16.250		17.015		17.761		18.527		19.292		20.058		20.804	
I	cm^4	1402218		1693272		2020483		2385747		2790955		3237996		3728756		4265120		4848970		5482190	
Wi	cm^3	32832		37318		42074		47096		52383		57933		63745		69817		76149		82739	
Ws	cm^3	43424		48901		54641		60640		66897		73411		80180		87203		94480		102011	
M self	kNm	337.5		355.5		374.0		392.5		411.0		429.0		447.5		466.0		484.5		502.5	
Mdesign	kNm	1035.0		1054.5		1074.0		1093.4		1112.9		1132.3		1151.7		1171.1		1190.5		1209.9	
Msdu	kNm	2007.0		2032.1		2057.2		2082.2		2107.2		2132.2		2157.1		2182.0		2206.8		2231.6	
Pi	kN									2280		2070		1960		1890		1810		1750	
e	cm									41.28		46.28		49.74		52.34		55.50		58.08	
Ap	mm^2									2100		1820		1680		1680		1540		1540	
n	strands									15		13		12		12		11		11	
σpi	MPa									1086		1137		1167		1125		1175		1136	
	%									65		68		70		67		70		68	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa									-7.27	-5.82	-7.14	-5.71	-6.80	-5.44	-6.38	-5.10	-6.05	-4.84	-5.70	-4.56
										24.77	19.81	22.44	17.96	20.66	16.53	19.14	15.31	17.77	14.22	16.55	13.24
σ at span	MPa									-1.13	10.82	-1.30	9.71	-1.21	8.93	-1.03	8.33	-0.93	7.76	-0.77	7.30
										16.92	-1.43	15.04	-1.59	13.64	-1.54	12.46	-1.46	11.41	-1.42	10.48	-1.38
Debonded	strands									13		11		10		10		9		9	
	X1(m)									8.5		9.5		9.0		8.0		7.5		7.0	
σ at support	MPa									-0.97		-1.10		-1.13		-1.06		-1.10		-1.04	
										3.30		3.45		3.44		3.19		3.23		3.01	
σ at X1	MPa									-1.27		-1.31		-1.27		-1.25		-1.25		-1.22	
										17.10		15.06		13.71		12.73		11.80		11.02	
Mcr	kNm									1123.1		1133.0		1154.0		1177.3		1199.2		1220.4	
Mu	kNm									2129.4		2152.3		2190.5		2317.6		2270.8		2386.1	
Cost/girder	USD									657.1		631.4		625.0		639.0		632.6		647.1	
Cost	USD									9109.4		8716.2		8471.7		8531.7		8311.1		8437.1	

#	unit	G12 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2754		2904		3054		3204		3354		3504		3654		3804		3954		4104	
Self-weight	ton	13.973		14.718		15.484		16.250		17.015		17.761		18.527		19.292		20.058		20.804	
I	cm^4	1402218		1693272		2020483		2385747		2790955		3237996		3728756		4265120		4848970		5482190	
Wi	cm^3	32832		37318		42074		47096		52383		57933		63745		69817		76149		82739	
Ws	cm^3	43424		48901		54641		60640		66897		73411		80180		87203		94480		102011	
M self	kNm	337.5		355.5		374.0		392.5		411.0		429.0		447.5		466.0		484.5		502.5	
Mdesign	kNm	1035.0		1054.5		1074.0		1093.4		1112.9		1132.3		1151.7		1171.1		1190.5		1209.9	
Msdu	kNm	2007.0		2032.1		2057.2		2082.2		2107.2		2132.2		2157.1		2182.0		2206.8		2231.6	
Pi	kN	2810		2570		2360		2210		2085		1970		1880		1790		1720		1640	
e	cm	30.60		34.20		38.02		41.01		44.05		47.14		49.74		52.91		55.50		58.76	
Ap	mm^2	2660		2380		2100		1960		1820		1680		1680		1540		1540		1400	
n	strands	19		17		15		14		13		12		12		11		11		10	
σpi	MPa	1056		1080		1124		1128		1146		1173		1119		1162		1117		1171	
	%	63		65		67		68		69		70		67		70		67		70	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-9.60	-7.68	-9.12	-7.30	-8.69	-6.95	-8.05	-6.44	-7.51	-6.01	-7.03	-5.62	-6.52	-5.21	-6.16	-4.92	-5.75	-4.60	-5.45	-4.36
		36.39	29.11	32.40	25.92	29.05	23.24	26.14	20.91	23.75	19.00	21.65	17.32	19.81	15.85	18.27	14.62	16.89	13.51	15.64	12.51
σ at span	MPa	-1.83	16.16	-1.85	14.26	-1.85	12.70	-1.58	11.59	-1.37	10.63	-1.18	9.80	-0.94	9.15	-0.81	8.51	-0.63	8.00	-0.52	7.50
		26.11	-2.41	22.88	-2.33	20.16	-2.28	17.81	-2.30	15.90	-2.24	14.25	-2.22	12.79	-2.22	11.60	-2.16	10.52	-2.13	9.57	-2.11
Debonded	strands	15		13		12		11		10		9		9		8		8		7	
	X1(m)	8.0		8.0		8.0		7.5		7.0		6.5		6.0		5.5		5.0		5.0	
σ at support	MPa	-2.02		-2.15		-1.74		-1.72		-1.73		-1.76		-1.63		-1.68		-1.57		-1.64	
		7.66		7.62		5.81		5.60		5.48		5.41		4.95		4.98		4.61		4.69	
σ at X1	MPa	-2.14		-2.15		-2.12		-1.98		-1.92		-1.90		-1.83		-1.89		-1.91		-1.76	
		26.52		23.26		20.52		18.33		16.61		15.15		13.92		12.95		12.11		11.09	
Mcr	kNm	1044.8		1066.4		1087.5		1105.5		1127.2		1147.1		1166.2		1188.7		1209.8		1229.8	
Mu	kNm	2047.7		2093.9		2105.9		2166.3		2187.2		2167.6		2293.4		2240.5		2355.8		2269.7	
Cost/girder	USD	735.2		711.5		687.7		684.3		680.9		677.6		695.1		691.7		709.2		706.3	
Cost	USD	10286.6		9689.5		9308.3		9111.8		8927.2		8754.6		8916.6		8762.1		8930.1		8835.5	





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h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2880		3030		3180		3330		3480		3630		3780		3930		4080		4230	
Self-weight	ton	14.614		15.359		16.125		16.891		17.657		18.402		19.168		19.934		20.700		21.445	
I	cm^4	1470858		1775832		2118437		2500578		2924160		3391080		3903232		4462507		5070796		5729983	
Wi	cm^3	33638		38241		43119		48270		53691		59379		65333		71551		78032		84775	
Ws	cm^3	47032		52912		59058		65467		72136		79063		86248		93687		101382		109330	
M self	kNm	353.0		371.0		389.5		408.0		426.5		444.5		463.0		481.5		500.0		518.0	
Mdesign	kNm	1107.8		1127.4		1147.0		1166.5		1186.0		1205.5		1225.0		1244.5		1264.0		1283.4	
Msdu	kNm	2155.5		2180.7		2205.8		2230.9		2256.0		2281.0		2306.0		2330.9		2355.8		2380.6	
Pi	kN					2605		2390		2235		2120		2030		1930		1855		1775	
e	cm					37.07		41.14		44.82		47.88		50.51		53.62		56.23		59.41	
Ap	mm^2					2380		2100		1960		1820		1820		1680		1680		1540	
n	strands					17		15		14		13		13		12		12		11	
σpi	MPa					1095		1138		1140		1165		1115		1149		1104		1153	
	%					66		68		68		70		67		69		66		69	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa					-8.16	-6.53	-7.84	-6.27	-7.46	-5.97	-7.00	-5.60	-6.52	-5.21	-6.14	-4.91	-5.74	-4.59	-5.45	-4.36
						30.59	24.47	27.55	22.04	25.08	20.06	22.93	18.35	21.06	16.85	19.37	15.50	17.91	14.33	16.64	13.31
σ at span	MPa					-1.56	12.89	-1.61	11.54	-1.55	10.47	-1.38	9.65	-1.15	8.99	-1.00	8.38	-0.81	7.87	-0.71	7.38
						21.55	-2.13	19.09	-2.13	17.14	-2.03	15.45	-1.95	13.98	-1.90	12.64	-1.89	11.51	-1.87	10.53	-1.83
Debonded	strands					14		12		11		11		10		9		9		8	
	X1(m)					9.0		9.5		9.0		8.5		7.5		7.0		6.5		6.0	
σ at support	MPa					-1.44		-1.57		-1.60		-1.08		-1.50		-1.53		-1.44		-1.49	
						5.40		5.51		5.37		3.53		4.86		4.84		4.48		4.54	
σ at X1	MPa					-1.63		-1.63		-1.61		-1.50		-1.49		-1.46		-1.41		-1.47	
						21.64		19.12		17.22		15.62		14.42		13.25		12.29		11.50	
Mcr	kNm					1148.6		1166.5		1189.6		1211.8		1233.6		1252.2		1272.4		1293.6	
Mu	kNm					2259.7		2267.3		2312.9		2308.0		2444.3		2406.0		2531.8		2460.0	
Cost/girder	USD					707.4		682.4		677.2		672.0		687.2		682.0		697.7		692.5	
Cost	USD					9068.6		8655.4		8438.9		8326.9		8301.6		8118.1		8246.8		8079.8	

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<tr><td>Msdu</td><td>kNm</td><td colspan="2">2155.5</td><td colspan="2">2180.7</td><td colspan="2">2205.8</td><td colspan="2">2230.9</td><td colspan="2">2256.0</td><td colspan="2">2281.0</td><td colspan="2">2306.0</td><td colspan="2">2330.9</td><td colspan="2">2355.8</td><td colspan="2">2380.6</td></tr>
<tr><td>Pi</td><td>kN</td><td colspan="2">2970</td><td colspan="2">2720</td><td colspan="2">2585</td><td colspan="2">2370</td><td colspan="2">2210</td><td colspan="2">2090</td><td colspan="2">1980</td><td colspan="2">1900</td><td colspan="2">1805</td><td colspan="2">1735</td></tr>
<tr><td>e</td><td>cm</td><td colspan="2">31.23</td><td colspan="2">34.77</td><td colspan="2">37.07</td><td colspan="2">41.14</td><td colspan="2">44.82</td><td colspan="2">47.88</td><td colspan="2">50.99</td><td colspan="2">53.62</td><td colspan="2">56.80</td><td colspan="2">59.41</td></tr>
<tr><td>Ap</td><td>mm^2</td><td colspan="2">2800</td><td colspan="2">2520</td><td colspan="2">2240</td><td colspan="2">2100</td><td colspan="2">1960</td><td colspan="2">1820</td><td colspan="2">1680</td><td colspan="2">1680</td><td colspan="2">1540</td><td colspan="2">1540</td></tr>
<tr><td>n</td><td>strands</td><td colspan="2">20</td><td colspan="2">18</td><td colspan="2">16</td><td colspan="2">15</td><td colspan="2">14</td><td colspan="2">13</td><td colspan="2">12</td><td colspan="2">12</td><td colspan="2">11</td><td colspan="2">11</td></tr>
<tr><td rowspan="2">σpi</td><td>MPa</td><td colspan="2">1061</td><td colspan="2">1079</td><td colspan="2">1154</td><td colspan="2">1129</td><td colspan="2">1128</td><td colspan="2">1148</td><td colspan="2">1179</td><td colspan="2">1131</td><td colspan="2">1172</td><td colspan="2">1127</td></tr>
<tr><td>%</td><td colspan="2">64</td><td colspan="2">65</td><td colspan="2">69</td><td colspan="2">68</td><td colspan="2">68</td><td colspan="2">69</td><td colspan="2">71</td><td colspan="2">68</td><td colspan="2">70</td><td colspan="2">67</td></tr>
<tr><td rowspan="2">σ limits</td><td rowspan="2">MPa</td><td>2.26</td><td>2.71</td><td>2.21</td><td>2.65</td><td>2.17</td><td>2.6</td><td>2.13</td><td>2.56</td><td>2.09</td><td>2.52</td><td>2.06</td><td>2.48</td><td>2.03</td><td>2.44</td><td>2</td><td>2.41</td><td>1.98</td><td>2.38</td><td>1.95</td><td>2.35</td></tr>
<tr><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td>-9.41</td><td>-7.53</td><td>-8.90</td><td>-7.12</td><td>-8.10</td><td>-6.48</td><td>-7.78</td><td>-6.22</td><td>-7.38</td><td>-5.90</td><td>-6.90</td><td>-5.52</td><td>-6.47</td><td>-5.17</td><td>-6.04</td><td>-4.83</td><td>-5.69</td><td>-4.55</td><td>-5.33</td><td>-4.26</td></tr>
<tr><td>37.89</td><td>30.31</td><td>33.71</td><td>26.97</td><td>30.35</td><td>24.28</td><td>27.32</td><td>21.85</td><td>24.80</td><td>19.84</td><td>22.61</td><td>18.09</td><td>20.69</td><td>16.55</td><td>19.07</td><td>15.26</td><td>17.56</td><td>14.05</td><td>16.26</td><td>13.01</td></tr>
<tr><td rowspan="2">σ at span</td><td rowspan="2">MPa</td><td>-1.90</td><td>16.03</td><td>-1.89</td><td>14.19</td><td>-1.50</td><td>12.94</td><td>-1.54</td><td>11.60</td><td>-1.47</td><td>10.54</td><td>-1.28</td><td>9.73</td><td>-1.10</td><td>9.03</td><td>-0.90</td><td>8.45</td><td>-0.76</td><td>7.92</td><td>-0.59</td><td>7.48</td></tr>
<tr><td>27.39</td><td>-2.63</td><td>24.01</td><td>-2.52</td><td>21.32</td><td>-2.32</td><td>18.86</td><td>-2.31</td><td>16.86</td><td>-2.25</td><td>15.12</td><td>-2.21</td><td>13.60</td><td>-2.20</td><td>12.34</td><td>-2.13</td><td>11.16</td><td>-2.15</td><td>10.15</td><td>-2.13</td></tr>
<tr><td rowspan="2">Debonded</td><td>strands</td><td colspan="2">16</td><td colspan="2">14</td><td colspan="2">12</td><td colspan="2">11</td><td colspan="2">11</td><td colspan="2">10</td><td colspan="2">9</td><td colspan="2">9</td><td colspan="2">8</td><td colspan="2">7</td></tr>
<tr><td>X1(m)</td><td colspan="2">8.0</td><td colspan="2">8.0</td><td colspan="2">7.0</td><td colspan="2">7.0</td><td colspan="2">7.0</td><td colspan="2">6.5</td><td colspan="2">6.0</td><td colspan="2">5.5</td><td colspan="2">5.5</td><td colspan="2">5.0</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td colspan="2">-1.88</td><td colspan="2">-1.98</td><td colspan="2">-2.02</td><td colspan="2">-2.07</td><td colspan="2">-1.58</td><td colspan="2">-1.59</td><td colspan="2">-1.62</td><td colspan="2">-1.51</td><td colspan="2">-1.55</td><td colspan="2">-1.94</td></tr>
<tr><td colspan="2">7.58</td><td colspan="2">7.49</td><td colspan="2">7.59</td><td colspan="2">7.28</td><td colspan="2">5.31</td><td colspan="2">5.22</td><td colspan="2">5.17</td><td colspan="2">4.77</td><td colspan="2">4.79</td><td colspan="2">5.91</td></tr>
<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2">-2.20</td><td colspan="2">-2.17</td><td colspan="2">-2.10</td><td colspan="2">-2.10</td><td colspan="2">-2.00</td><td colspan="2">-1.97</td><td colspan="2">-1.96</td><td colspan="2">-1.94</td><td colspan="2">-1.76</td><td colspan="2">-1.77</td></tr>
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<tr><td>Mcr</td><td>kNm</td><td colspan="2">1110.6</td><td colspan="2">1132.7</td><td colspan="2">1159.3</td><td colspan="2">1178.4</td><td colspan="2">1200.4</td><td colspan="2">1221.3</td><td colspan="2">1241.1</td><td colspan="2">1264.2</td><td colspan="2">1282.0</td><td colspan="2">1301.9</td></tr>
<tr><td>Mu</td><td>kNm</td><td colspan="2">2168.7</td><td colspan="2">2224.2</td><td colspan="2">2249.5</td><td colspan="2">2325.7</td><td colspan="2">2349.7</td><td colspan="2">2339.7</td><td colspan="2">2307.2</td><td colspan="2">2433.0</td><td colspan="2">2367.4</td><td colspan="2">2482.7</td></tr>
<tr><td>Cost/girder</td><td>USD</td><td colspan="2">771.2</td><td colspan="2">747.5</td><td colspan="2">722.7</td><td colspan="2">719.8</td><td colspan="2">716.9</td><td colspan="2">713.6</td><td colspan="2">710.2</td><td colspan="2">727.7</td><td colspan="2">724.8</td><td colspan="2">742.3</td></tr>
<tr><td>Cost</td><td>USD</td><td colspan="2">10059.4</td><td colspan="2">9366.0</td><td colspan="2">8796.7</td><td colspan="2">8688.0</td><td colspan="2">8656.3</td><td colspan="2">8492.6</td><td colspan="2">8339.9</td><td colspan="2">8488.4</td><td colspan="2">8396.2</td><td colspan="2">8495.2</td></tr>
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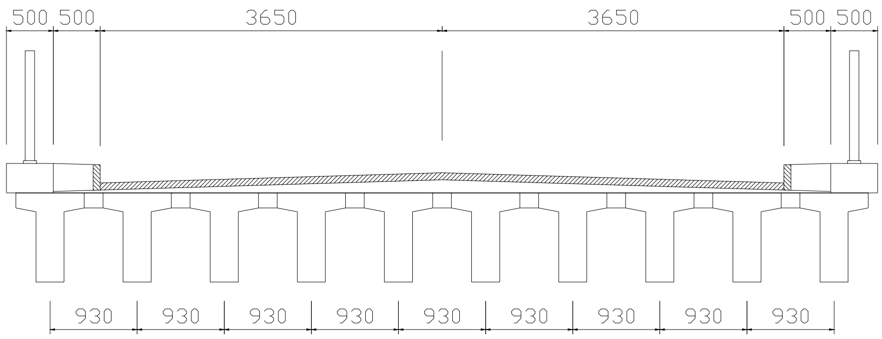

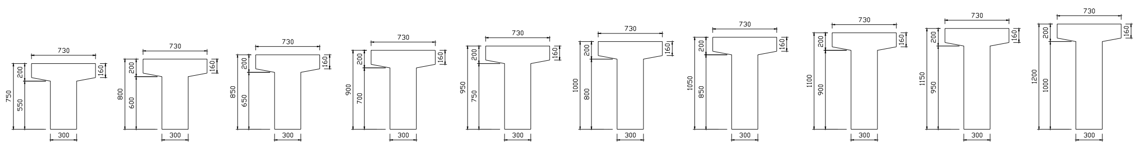

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h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3024		3174		3324		3474		3624		3774		3924		4074		4224		4374	
Self-weight	ton	15.339		16.105		16.850		17.616		18.382		19.148		19.893		20.659		21.425		22.190	
I	cm^4	1542654		1862500		2221614		2621924		3065349		3553801		4089186		4673407		5308360		5995941	
Wi	cm^3	34446		39169		44174		49459		55019		60852		66956		73329		79969		86875	
Ws	cm^3	51056		57397		64009		70887		78028		85430		93090		101008		109181		117609	
M self	kNm	370.5		389.0		407.0		425.5		444.0		462.5		480.5		499.0		517.5		536.0	
Mdesign	kNm	1192.9		1212.6		1232.2		1251.8		1271.4		1291.0		1310.6		1330.1		1349.6		1369.1	
Msdu	kNm	2329.9		2355.1		2380.3		2405.5		2430.6		2455.7		2480.7		2505.7		2530.6		2555.4	
Pi	kN					2800		2580		2405		2250		2150		2060		1965		1890	
e	cm					37.51		41.45		45.05		48.76		51.43		54.50		57.63		60.27	
Ap	mm^2					2520		2240		2100		1960		1960		1820		1680		1680	
n	strands					18		16		15		14		14		13		12		12	
σpi	MPa					1111		1152		1145		1148		1097		1132		1170		1125	
	%					67		69		69		69		66		68		70		67	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa					-7.98	-6.39	-7.66	-6.13	-7.25	-5.80	-6.88	-5.50	-6.40	-5.12	-6.06	-4.85	-5.72	-4.58	-5.36	-4.29
						32.20	25.76	29.05	23.24	26.33	21.06	23.99	19.19	21.99	17.59	20.37	16.29	18.81	15.05	17.43	13.95
σ at span	MPa					-1.63	12.86	-1.66	11.53	-1.56	10.50	-1.47	9.61	-1.24	8.96	-1.12	8.32	-0.98	7.79	-0.81	7.35
						22.99	-2.13	20.45	-2.07	18.26	-2.05	16.39	-2.02	14.82	-1.98	13.56	-1.85	12.34	-1.83	11.26	-1.81
Debonded	strands					15		13		12		11		11		10		9		9	
	X1(m)					9.0		10.0		9.0		8.5		7.5		7.5		7.0		6.5	
σ at support	MPa					-1.33		-1.44		-1.45		-1.47		-1.37		-1.40		-1.43		-1.34	
						5.37		5.45		5.27		5.14		4.71		4.70		4.70		4.36	
σ at X1	MPa					-1.69		-1.66		-1.62		-1.59		-1.56		-1.43		-1.41		-1.37	
						23.08		20.45		18.34		16.56		15.27		13.99		12.92		12.02	
Mcr	kNm					1233.6		1254.7		1274.0		1293.3		1314.0		1341.6		1361.5		1381.0	
Mu	kNm					2398.9		2404.1		2455.4		2480.8		2627.6		2598.8		2547.3		2673.1	
Cost/girder	USD					743.9		719.3		713.6		708.4		723.6		718.9		713.8		729.5	
Cost	USD					8698.5		8392.9		8126.1		7934.3		7986.3		7864.5		7697.6		7814.6	

#	unit	G10 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3024		3174		3324		3474		3624		3774		3924		4074		4224		4374	
Self-weight	ton	15.339		16.105		16.850		17.616		18.382		19.148		19.893		20.659		21.425		22.190	
I	cm^4	1542654		1862500		2221614		2621924		3065349		3553801		4089186		4673407		5308360		5995941	
Wi	cm^3	34446		39169		44174		49459		55019		60852		66956		73329		79969		86875	
Ws	cm^3	51056		57397		64009		70887		78028		85430		93090		101008		109181		117609	
M self	kNm	370.5		389.0		407.0		425.5		444.0		462.5		480.5		499.0		517.5		536.0	
Mdesign	kNm	1192.9		1212.6		1232.2		1251.8		1271.4		1291.0		1310.6		1330.1		1349.6		1369.1	
Msdu	kNm	2329.9		2355.1		2380.3		2405.5		2430.6		2455.7		2480.7		2505.7		2530.6		2555.4	
Pi	kN											2400		2280		2105		2030		1950	
e	cm											46.40		49.64		54.50		57.15		60.27	
Ap	mm^2											2100		1960		1820		1820		1680	
n	strands											15		14		13		13		12	
σpi	MPa											1143		1163		1157		1115		1161	
	%											68		70		69		67		70	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa											-6.68	-5.34	-6.35	-5.08	-6.19	-4.95	-5.82	-4.66	-5.53	-4.43
												24.66	19.73	22.71	18.17	20.81	16.65	19.31	15.45	17.99	14.39
σ at span	MPa											-1.26	9.77	-1.19	9.00	-1.25	8.22	-1.08	7.71	-0.98	7.21
												17.06	-1.49	15.54	-1.40	14.01	-1.49	12.84	-1.43	11.82	-1.37
Debonded	strands											12		12		11		11		10	
	X1(m)											9.0		8.5		9.5		8.0		8.0	
σ at support	MPa											-1.34		-0.91		-0.95		-0.90		-0.92	
												4.93		3.24		3.20		2.97		3.00	
σ at X1	MPa											-1.32		-1.30		-1.26		-1.27		-1.16	
												17.14		15.70		14.02		13.10		12.06	
Mcr	kNm											1297.9		1322.2		1334.8		1358.1		1381.4	
Mu	kNm											2464.8		2498.5		2532.7		2669.0		2616.8	
Cost/girder	USD											699.6		693.2		688.4		701.9		696.0	
Cost	USD											7986.2		7867.3		7833.5		7818.5		7679.7	

<table>
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<tr><td>A</td><td>cm^2</td><td colspan="2">3024</td><td colspan="2">3174</td><td colspan="2">3324</td><td colspan="2">3474</td><td colspan="2">3624</td><td colspan="2">3774</td><td colspan="2">3924</td><td colspan="2">4074</td><td colspan="2">4224</td><td colspan="2">4374</td></tr>
<tr><td>Self-weight</td><td>ton</td><td colspan="2">15.339</td><td colspan="2">16.105</td><td colspan="2">16.850</td><td colspan="2">17.616</td><td colspan="2">18.382</td><td colspan="2">19.148</td><td colspan="2">19.893</td><td colspan="2">20.659</td><td colspan="2">21.425</td><td colspan="2">22.190</td></tr>
<tr><td>I</td><td>cm^4</td><td colspan="2">1542654</td><td colspan="2">1862500</td><td colspan="2">2221614</td><td colspan="2">2621924</td><td colspan="2">3065349</td><td colspan="2">3553801</td><td colspan="2">4089186</td><td colspan="2">4673407</td><td colspan="2">5308360</td><td colspan="2">5995941</td></tr>
<tr><td>Wi</td><td>cm^3</td><td colspan="2">34446</td><td colspan="2">39169</td><td colspan="2">44174</td><td colspan="2">49459</td><td colspan="2">55019</td><td colspan="2">60852</td><td colspan="2">66956</td><td colspan="2">73329</td><td colspan="2">79969</td><td colspan="2">86875</td></tr>
<tr><td>Ws</td><td>cm^3</td><td colspan="2">51056</td><td colspan="2">57397</td><td colspan="2">64009</td><td colspan="2">70887</td><td colspan="2">78028</td><td colspan="2">85430</td><td colspan="2">93090</td><td colspan="2">101008</td><td colspan="2">109181</td><td colspan="2">117609</td></tr>
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<tr><td>Pi</td><td>kN</td><td colspan="2">3250</td><td colspan="2">2910</td><td colspan="2">2675</td><td colspan="2">2500</td><td colspan="2">2355</td><td colspan="2">2230</td><td colspan="2">2110</td><td colspan="2">2010</td><td colspan="2">1925</td><td colspan="2">1850</td></tr>
<tr><td>e</td><td>cm</td><td colspan="2">31.15</td><td colspan="2">35.45</td><td colspan="2">39.12</td><td colspan="2">42.39</td><td colspan="2">45.71</td><td colspan="2">48.76</td><td colspan="2">51.84</td><td colspan="2">54.50</td><td colspan="2">57.63</td><td colspan="2">60.27</td></tr>
<tr><td>Ap</td><td>mm^2</td><td colspan="2">3080</td><td colspan="2">2660</td><td colspan="2">2380</td><td colspan="2">2240</td><td colspan="2">2100</td><td colspan="2">1960</td><td colspan="2">1820</td><td colspan="2">1820</td><td colspan="2">1680</td><td colspan="2">1680</td></tr>
<tr><td>n</td><td>strands</td><td colspan="2">22</td><td colspan="2">19</td><td colspan="2">17</td><td colspan="2">16</td><td colspan="2">15</td><td colspan="2">14</td><td colspan="2">13</td><td colspan="2">13</td><td colspan="2">12</td><td colspan="2">12</td></tr>
<tr><td rowspan="2">σpi</td><td>MPa</td><td colspan="2">1055</td><td colspan="2">1094</td><td colspan="2">1124</td><td colspan="2">1116</td><td colspan="2">1121</td><td colspan="2">1138</td><td colspan="2">1159</td><td colspan="2">1104</td><td colspan="2">1146</td><td colspan="2">1101</td></tr>
<tr><td>%</td><td colspan="2">63</td><td colspan="2">66</td><td colspan="2">67</td><td colspan="2">67</td><td colspan="2">67</td><td colspan="2">68</td><td colspan="2">69</td><td colspan="2">66</td><td colspan="2">69</td><td colspan="2">66</td></tr>
<tr><td rowspan="2">σ limits</td><td rowspan="2">MPa</td><td>2.26</td><td>2.71</td><td>2.21</td><td>2.65</td><td>2.17</td><td>2.6</td><td>2.13</td><td>2.56</td><td>2.09</td><td>2.52</td><td>2.06</td><td>2.48</td><td>2.03</td><td>2.44</td><td>2</td><td>2.41</td><td>1.98</td><td>2.38</td><td>1.95</td><td>2.35</td></tr>
<tr><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td>-9.08</td><td>-7.27</td><td>-8.80</td><td>-7.04</td><td>-8.30</td><td>-6.64</td><td>-7.75</td><td>-6.20</td><td>-7.30</td><td>-5.84</td><td>-6.82</td><td>-5.46</td><td>-6.37</td><td>-5.10</td><td>-5.91</td><td>-4.73</td><td>-5.60</td><td>-4.48</td><td>-5.25</td><td>-4.20</td></tr>
<tr><td>40.14</td><td>32.11</td><td>35.51</td><td>28.40</td><td>31.74</td><td>25.39</td><td>28.62</td><td>22.90</td><td>26.06</td><td>20.85</td><td>23.78</td><td>19.02</td><td>21.71</td><td>17.37</td><td>19.87</td><td>15.90</td><td>18.43</td><td>14.74</td><td>17.06</td><td>13.65</td></tr>
<tr><td rowspan="2">σ at span</td><td rowspan="2">MPa</td><td>-1.82</td><td>16.10</td><td>-2.03</td><td>14.08</td><td>-1.94</td><td>12.61</td><td>-1.75</td><td>11.46</td><td>-1.61</td><td>10.46</td><td>-1.41</td><td>9.66</td><td>-1.21</td><td>8.98</td><td>-0.97</td><td>8.44</td><td>-0.86</td><td>7.88</td><td>-0.69</td><td>7.44</td></tr>
<tr><td>29.38</td><td>-2.52</td><td>25.57</td><td>-2.55</td><td>22.52</td><td>-2.50</td><td>20.02</td><td>-2.41</td><td>17.99</td><td>-2.26</td><td>16.18</td><td>-2.19</td><td>14.54</td><td>-2.20</td><td>13.07</td><td>-2.24</td><td>11.96</td><td>-2.13</td><td>10.89</td><td>-2.11</td></tr>
<tr><td rowspan="2">Debonded</td><td>strands</td><td colspan="2">17</td><td colspan="2">15</td><td colspan="2">13</td><td colspan="2">12</td><td colspan="2">11</td><td colspan="2">10</td><td colspan="2">9</td><td colspan="2">9</td><td colspan="2">8</td><td colspan="2">8</td></tr>
<tr><td>X1(m)</td><td colspan="2">8.0</td><td colspan="2">8.5</td><td colspan="2">8.5</td><td colspan="2">7.5</td><td colspan="2">7.5</td><td colspan="2">7.0</td><td colspan="2">6.5</td><td colspan="2">5.5</td><td colspan="2">5.5</td><td colspan="2">5.0</td></tr>
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<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2">-2.11</td><td colspan="2">-2.18</td><td colspan="2">-2.09</td><td colspan="2">-2.13</td><td colspan="2">-1.96</td><td colspan="2">-1.89</td><td colspan="2">-1.84</td><td colspan="2">-1.97</td><td colspan="2">-1.82</td><td colspan="2">-1.83</td></tr>
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<tr><td>Mu</td><td>kNm</td><td colspan="2">2343.7</td><td colspan="2">2361.2</td><td colspan="2">2393.1</td><td colspan="2">2475.0</td><td colspan="2">2514.0</td><td colspan="2">2513.6</td><td colspan="2">2490.7</td><td colspan="2">2627.0</td><td colspan="2">2571.3</td><td colspan="2">2697.2</td></tr>
<tr><td>Cost/girder</td><td>USD</td><td colspan="2">830.3</td><td colspan="2">786.1</td><td colspan="2">762.4</td><td colspan="2">758.5</td><td colspan="2">755.6</td><td colspan="2">752.2</td><td colspan="2">748.8</td><td colspan="2">765.8</td><td colspan="2">763.0</td><td colspan="2">780.5</td></tr>
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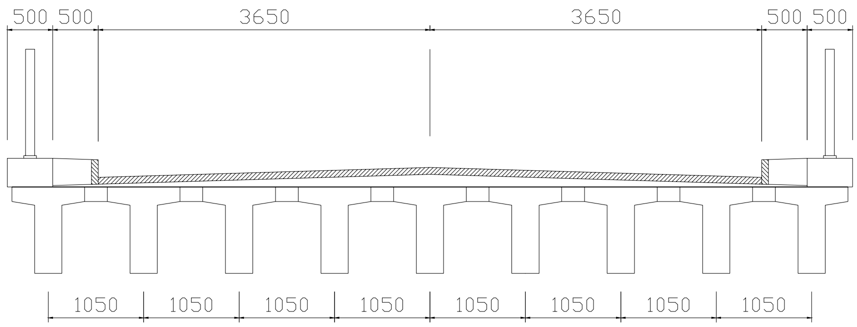

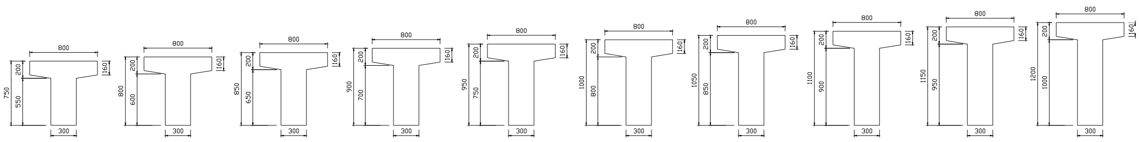

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h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3150		3300		3450		3600		3750		3900		4050		4200		4350		4500	
Self-weight	ton	15.980		16.746		17.492		18.257		19.023		19.769		20.534		21.300		22.066		22.832	
I	cm^4	1600391		1932415		2305102		2720400		3180246		3686566		4241282		4846304		5503543		6214900	
Wi	cm^3	35071		39889		44996		50386		56058		62008		68233		74732		81502		88541	
Ws	cm^3	54495		61238		68258		75547		83103		90921		98999		107336		115930		124779	
M self	kNm	386.0		404.5		422.5		441.0		459.5		477.5		496.0		514.5		533.0		551.5	
Mdesign	kNm	1298.8		1318.6		1338.3		1358.1		1377.8		1397.5		1417.2		1436.8		1456.4		1476.0	
Msdu	kNm	2544.0		2569.4		2594.7		2620.0		2645.2		2670.4		2695.4		2720.5		2745.5		2770.4	
Pi	kN							2930		2705		2540		2325		2215		2120		2040	
e	cm							39.52		43.50		46.95		52.16		55.22		58.30		60.96	
Ap	mm^2							2660		2380		2240		2100		1960		1820		1820	
n	strands							19		17		16		15		14		13		13	
σpi	MPa							1102		1137		1134		1107		1130		1165		1121	
	%							66		68		68		66		68		70		67	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa							-7.19	-5.75	-6.95	-5.56	-6.60	-5.28	-6.51	-5.21	-6.12	-4.90	-5.79	-4.63	-5.43	-4.35
								31.12	24.90	28.20	22.56	25.74	20.60	23.51	18.81	21.64	17.31	20.04	16.03	18.58	14.86
σ at span	MPa							-1.35	12.23	-1.42	11.02	-1.35	10.09	-1.50	9.11	-1.33	8.49	-1.19	7.93	-1.01	7.48
								22.37	-2.06	20.01	-2.01	18.04	-1.94	16.24	-1.96	14.76	-1.91	13.50	-1.84	12.35	-1.81
Debonded	strands							15		14		13		12		11		10		10	
	X1(m)							8.0		8.5		8.0		9.0		8.0		7.5		7.0	
σ at support	MPa							-1.51		-1.23		-1.24		-1.30		-1.31		-1.34		-1.25	
								6.55		4.98		4.83		4.70		4.64		4.62		4.29	
σ at X1	MPa							-1.58		-1.54		-1.56		-1.55		-1.52		-1.48		-1.41	
								22.72		20.19		18.35		16.32		15.03		13.91		12.91	
Mcr	kNm							1361.7		1382.2		1404.9		1422.1		1443.4		1467.5		1488.7	
Mu	kNm							2693.0		2683.1		2731.0		2808.2		2789.4		2748.0		2884.3	
Cost/girder	USD							793.5		768.5		763.3		759.6		753.9		748.8		764.5	
Cost	USD							8149.9		7910.8		7733.7		7727.5		7505.4		7346.3		7447.1	

#	unit	G09 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3150		3300		3450		3600		3750		3900		4050		4200		4350		4500	
Self-weight	ton	15.980		16.746		17.492		18.257		19.023		19.769		20.534		21.300		22.066		22.832	
I	cm^4	1600391		1932415		2305102		2720400		3180246		3686566		4241282		4846304		5503543		6214900	
Wi	cm^3	35071		39889		44996		50386		56058		62008		68233		74732		81502		88541	
Ws	cm^3	54495		61238		68258		75547		83103		90921		98999		107336		115930		124779	
M self	kNm	386.0		404.5		422.5		441.0		459.5		477.5		496.0		514.5		533.0		551.5	
Mdesign	kNm	1298.8		1318.6		1338.3		1358.1		1377.8		1397.5		1417.2		1436.8		1456.4		1476.0	
Msdu	kNm	2544.0		2569.4		2594.7		2620.0		2645.2		2670.4		2695.4		2720.5		2745.5		2770.4	
Pi	kN													2495		2360		2245		2090	
e	cm													49.03		52.85		56.10		60.96	
Ap	mm^2													2240		2100		1960		1820	
n	strands													16		15		14		13	
σpi	MPa													1114		1124		1145		1148	
	%													67		67		69		69	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa													-6.20	-4.96	-6.00	-4.80	-5.70	-4.56	-5.57	-4.45
														24.09	19.27	22.31	17.85	20.61	16.49	19.03	15.23
σ at span	MPa													-1.19	9.36	-1.21	8.59	-1.11	8.00	-1.15	7.38
														16.82	-1.50	15.42	-1.38	14.07	-1.38	12.81	-1.44
Debonded	strands													13		12		11		11	
	X1(m)													8.5		9.0		8.5		8.5	
σ at support	MPa													-1.16		-1.20		-1.22		-0.86	
														4.52		4.46		4.42		2.93	
σ at X1	MPa													-1.30		-1.26		-1.21		-1.25	
														16.98		15.49		14.22		12.95	
Mcr	kNm													1422.5		1449.8		1468.9		1482.1	
Mu	kNm													2778.6		2822.2		2813.8		2824.0	
Cost/girder	USD													747.6		742.2		735.8		730.0	
Cost	USD													7646.4		7570.9		7387.5		7334.6	

<table>
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<tr><td>A</td><td>cm^2</td><td colspan="2">3150</td><td colspan="2">3300</td><td colspan="2">3450</td><td colspan="2">3600</td><td colspan="2">3750</td><td colspan="2">3900</td><td colspan="2">4050</td><td colspan="2">4200</td><td colspan="2">4350</td><td colspan="2">4500</td></tr>
<tr><td>Self-weight</td><td>ton</td><td colspan="2">15.980</td><td colspan="2">16.746</td><td colspan="2">17.492</td><td colspan="2">18.257</td><td colspan="2">19.023</td><td colspan="2">19.769</td><td colspan="2">20.534</td><td colspan="2">21.300</td><td colspan="2">22.066</td><td colspan="2">22.832</td></tr>
<tr><td>I</td><td>cm^4</td><td colspan="2">1600391</td><td colspan="2">1932415</td><td colspan="2">2305102</td><td colspan="2">2720400</td><td colspan="2">3180246</td><td colspan="2">3686566</td><td colspan="2">4241282</td><td colspan="2">4846304</td><td colspan="2">5503543</td><td colspan="2">6214900</td></tr>
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<tr><td>%</td><td colspan="2">62</td><td colspan="2">63</td><td colspan="2">66</td><td colspan="2">69</td><td colspan="2">68</td><td colspan="2">68</td><td colspan="2">65</td><td colspan="2">67</td><td colspan="2">68</td><td colspan="2">66</td></tr>
<tr><td rowspan="2">σ limits</td><td rowspan="2">MPa</td><td>2.26</td><td>2.71</td><td>2.21</td><td>2.65</td><td>2.17</td><td>2.6</td><td>2.13</td><td>2.56</td><td>2.09</td><td>2.52</td><td>2.06</td><td>2.48</td><td>2.03</td><td>2.44</td><td>2</td><td>2.41</td><td>1.98</td><td>2.38</td><td>1.95</td><td>2.35</td></tr>
<tr><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td><td>36</td><td>32</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td>-8.85</td><td>-7.08</td><td>-8.63</td><td>-6.90</td><td>-8.30</td><td>-6.64</td><td>-7.89</td><td>-6.31</td><td>-7.33</td><td>-5.87</td><td>-6.90</td><td>-5.52</td><td>-6.41</td><td>-5.13</td><td>-6.02</td><td>-4.82</td><td>-5.65</td><td>-4.52</td><td>-5.31</td><td>-4.25</td></tr>
<tr><td>43.11</td><td>34.49</td><td>38.21</td><td>30.57</td><td>33.97</td><td>27.17</td><td>30.78</td><td>24.62</td><td>27.72</td><td>22.18</td><td>25.29</td><td>20.23</td><td>23.16</td><td>18.53</td><td>21.30</td><td>17.04</td><td>19.57</td><td>15.65</td><td>18.17</td><td>14.54</td></tr>
<tr><td rowspan="2">σ at span</td><td rowspan="2">MPa</td><td>-1.77</td><td>16.75</td><td>-2.02</td><td>14.63</td><td>-2.11</td><td>12.97</td><td>-2.05</td><td>11.67</td><td>-1.81</td><td>10.71</td><td>-1.65</td><td>9.85</td><td>-1.40</td><td>9.19</td><td>-1.23</td><td>8.57</td><td>-1.05</td><td>8.04</td><td>-0.89</td><td>7.58</td></tr>
<tr><td>32.10</td><td>-2.55</td><td>28.07</td><td>-2.49</td><td>24.58</td><td>-2.57</td><td>22.03</td><td>-2.33</td><td>19.52</td><td>-2.40</td><td>17.59</td><td>-2.30</td><td>15.89</td><td>-2.24</td><td>14.41</td><td>-2.19</td><td>13.03</td><td>-2.22</td><td>11.94</td><td>-2.14</td></tr>
<tr><td rowspan="2">Debonded</td><td>strands</td><td colspan="2">19</td><td colspan="2">17</td><td colspan="2">15</td><td colspan="2">13</td><td colspan="2">12</td><td colspan="2">11</td><td colspan="2">11</td><td colspan="2">10</td><td colspan="2">9</td><td colspan="2">9</td></tr>
<tr><td>X1(m)</td><td colspan="2">7.5</td><td colspan="2">8.5</td><td colspan="2">9.5</td><td colspan="2">9.0</td><td colspan="2">8.0</td><td colspan="2">7.5</td><td colspan="2">6.5</td><td colspan="2">6.0</td><td colspan="2">6.0</td><td colspan="2">5.5</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td colspan="2">-2.13</td><td colspan="2">-1.96</td><td colspan="2">-1.75</td><td colspan="2">-1.86</td><td colspan="2">-1.83</td><td colspan="2">-1.84</td><td colspan="2">-1.71</td><td colspan="2">-1.72</td><td colspan="2">-1.74</td><td colspan="2">-1.63</td></tr>
<tr><td colspan="2">10.35</td><td colspan="2">8.68</td><td colspan="2">7.15</td><td colspan="2">7.24</td><td colspan="2">6.93</td><td colspan="2">6.74</td><td colspan="2">6.18</td><td colspan="2">6.09</td><td colspan="2">6.02</td><td colspan="2">5.59</td></tr>
<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2">-2.21</td><td colspan="2">-2.17</td><td colspan="2">-2.13</td><td colspan="2">-2.11</td><td colspan="2">-2.03</td><td colspan="2">-1.98</td><td colspan="2">-2.01</td><td colspan="2">-2.00</td><td colspan="2">-1.79</td><td colspan="2">-1.79</td></tr>
<tr><td colspan="2">32.79</td><td colspan="2">28.30</td><td colspan="2">24.60</td><td colspan="2">22.11</td><td colspan="2">19.85</td><td colspan="2">18.07</td><td colspan="2">16.78</td><td colspan="2">15.52</td><td colspan="2">14.07</td><td colspan="2">13.20</td></tr>
<tr><td>Mcr</td><td>kNm</td><td colspan="2">1304.5</td><td colspan="2">1325.2</td><td colspan="2">1339.9</td><td colspan="2">1369.6</td><td colspan="2">1384.3</td><td colspan="2">1408.5</td><td colspan="2">1430.9</td><td colspan="2">1453.4</td><td colspan="2">1469.6</td><td colspan="2">1494.9</td></tr>
<tr><td>Mu</td><td>kNm</td><td colspan="2">2569.9</td><td colspan="2">2626.5</td><td colspan="2">2621.5</td><td colspan="2">2620.0</td><td colspan="2">2665.1</td><td colspan="2">2685.2</td><td colspan="2">2842.4</td><td colspan="2">2819.2</td><td colspan="2">2773.8</td><td colspan="2">2910.1</td></tr>
<tr><td>Cost/girder</td><td>USD</td><td colspan="2">907.5</td><td colspan="2">863.9</td><td colspan="2">820.2</td><td colspan="2">796.0</td><td colspan="2">792.1</td><td colspan="2">788.7</td><td colspan="2">805.7</td><td colspan="2">802.3</td><td colspan="2">799.5</td><td colspan="2">817.0</td></tr>
<tr><td>Cost</td><td>USD</td><td colspan="2">9952.7</td><td colspan="2">8998.9</td><td colspan="2">8579.2</td><td colspan="2">8135.8</td><td colspan="2">7920.9</td><td colspan="2">7773.4</td><td colspan="2">7836.4</td><td colspan="2">7707.0</td><td colspan="2">7627.1</td><td colspan="2">7748.6</td></tr>
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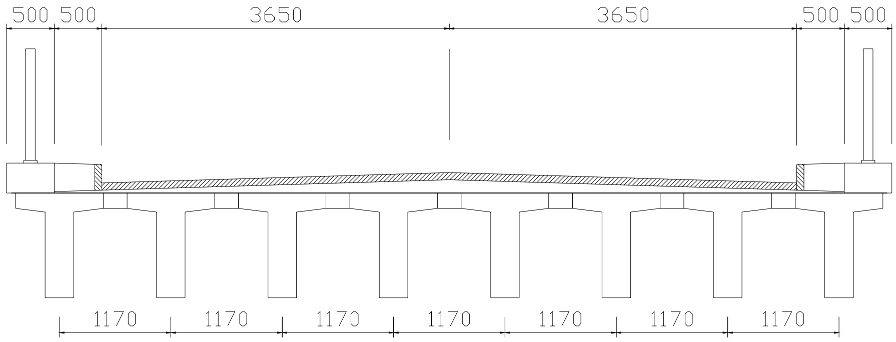
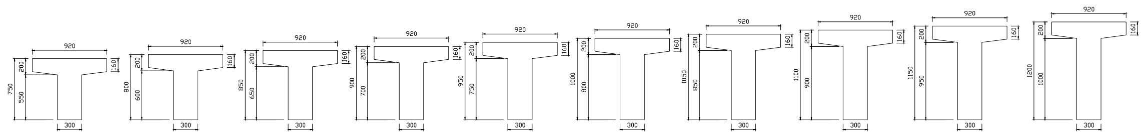
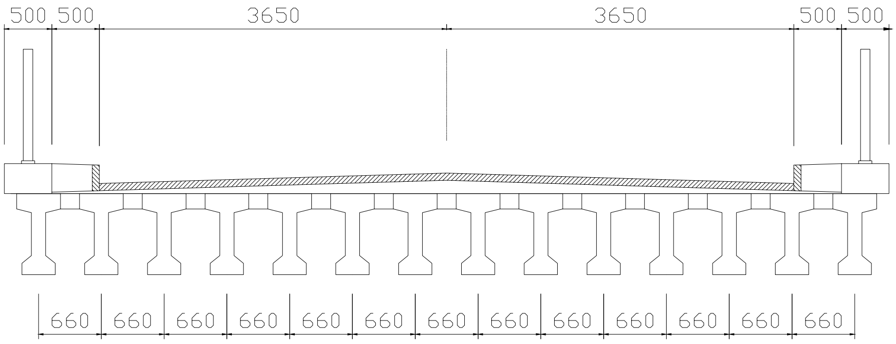


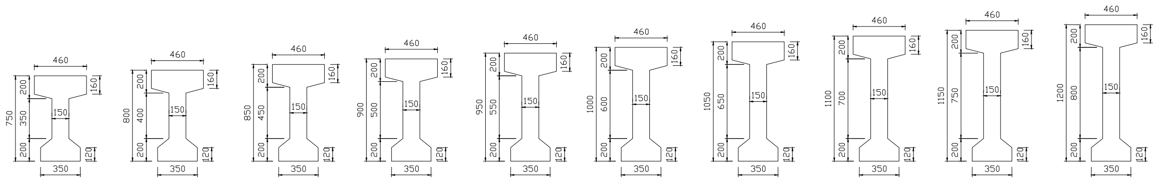


#	unit	G08 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	3366	3516	3666	3816	3966	4116	4266	4416	4566	4716
Self-weight	ton	17.078	17.823	18.589	19.355	20.120	20.866	21.632	22.397	23.163	23.909
I	cm^4	1689918	2041192	2435429	2874621	3360741	3895749	4481593	5120209	5813528	6563471
Wi	cm^3	36004	40965	46225	51779	57623	63753	70167	76862	83835	91083
Ws	cm^3	60219	67651	75369	83365	91631	100165	108962	118020	127336	136910
M self	kNm	412.5	430.5	449.0	467.5	486.0	504.0	522.5	541.0	559.5	577.5
Mdesign	kNm	1344.6	1364.5	1384.5	1404.5	1424.4	1444.3	1464.1	1484.0	1503.8	1523.6
Msdu	kNm	2690.7	2716.4	2741.9	2767.5	2792.9	2818.4	2843.7	2869.0	2894.2	2919.4
Pi	kN				3010	2780	2560	2400	2270	2160	2080
e	cm				40.52	44.43	49.05	52.93	56.62	59.70	62.42
Ap	mm^2				2800	2520	2380	2240	2100	1960	1960
n	strands				20	18	17	16	15	14	14
σpi	MPa				1075	1103	1076	1071	1081	1102	1061
	%				64	66	64	64	65	66	64
σ limits	MPa	1.76 2.26	1.72 2.21	1.69 2.17	1.66 2.13	1.63 2.09	1.6 2.06	1.58 2.03	1.55 2	1.53 1.98	1.51 1.95
		24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24
σ at support	MPa				-6.74 -5.39	-6.47 -5.18	-6.32 -5.05	-6.03 -4.83	-5.75 -4.60	-5.40 -4.32	-5.07 -4.06
					31.44 25.15	28.44 22.76	25.92 20.73	23.73 18.98	21.86 17.49	20.11 16.09	18.66 14.93
σ at span	MPa				-1.13 11.45	-1.17 10.37	-1.28 9.37	-1.24 8.61	-1.17 7.97	-1.00 7.49	-0.85 7.07
					22.41 -1.97	20.01 -1.96	18.01 -1.92	16.28 -1.88	14.82 -1.82	13.44 -1.85	12.32 -1.80
Debonded	strands				16	14	13	12	11	11	10
	X1(m)				7.0	7.5	7.5	7.5	7.5	7.0	6.5
σ at support	MPa				-1.35	-1.44	-1.49	-1.51	-1.53	-1.16	-1.45
					6.29	6.32	6.10	5.93	5.83	4.31	5.33
σ at X1	MPa				-1.64	-1.50	-1.60	-1.54	-1.45	-1.40	-1.37
					23.23	20.54	18.50	16.75	15.26	14.04	13.10
Mcr	kNm				1412.7	1431.9	1453.1	1474.5	1498.2	1514.5	1537.7
Mu	kNm				2852.3	2836.2	2933.9	2977.8	2988.8	2956.6	3103.3
Cost/girder	USD				836.7	811.7	807.0	802.3	797.6	792.5	808.2
Cost	USD				7534.0	7273.5	7176.0	7078.6	6981.1	6899.7	6933.3

#	unit	G08 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3366		3516		3666		3816		3966		4116		4266		4416		4566		4716	
Self-weight	ton	17.078		17.823		18.589		19.355		20.120		20.866		21.632		22.397		23.163		23.909	
I	cm^4	1689918		2041192		2435429		2874621		3360741		3895749		4481593		5120209		5813528		6563471	
Wi	cm^3	36004		40965		46225		51779		57623		63753		70167		76862		83835		91083	
Ws	cm^3	60219		67651		75369		83365		91631		100165		108962		118020		127336		136910	
M self	kNm	412.5		430.5		449.0		467.5		486.0		504.0		522.5		541.0		559.5		577.5	
Mdesign	kNm	1344.6		1364.5		1384.5		1404.5		1424.4		1444.3		1464.1		1484.0		1503.8		1523.6	
Msdu	kNm	2690.7		2716.4		2741.9		2767.5		2792.9		2818.4		2843.7		2869.0		2894.2		2919.4	
Pi	kN													2505		2310		2215		2140	
e	cm													51.37		56.62		59.70		62.42	
Ap	mm^2													2240		2100		1960		1960	
n	strands													16		15		14		14	
σpi	MPa													1118		1100		1130		1092	
	%													67		66		68		65	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa													-5.94	-4.75	-5.85	-4.68	-5.53	-4.43	-5.22	-4.18
														24.21	19.37	22.25	17.80	20.62	16.50	19.20	15.36
σ at span	MPa													-1.14	8.69	-1.27	7.89	-1.14	7.38	-1.00	6.95
														16.76	-1.50	15.21	-1.51	13.95	-1.44	12.86	-1.37
Debonded	strands													13		12		11		11	
	X1(m)													8.5		9.5		8.5		8.0	
σ at support	MPa													-1.11		-1.17		-1.19		-1.12	
														4.54		4.45		4.42		4.12	
σ at X1	MPa													-1.25		-1.28		-1.24		-1.17	
														16.93		15.23		14.10		13.12	
Mcr	kNm													1469.7		1487.4		1511.7		1537.0	
Mu	kNm													2845.9		2919.0		2895.7		3042.5	
Cost/girder	USD													769.2		764.3		757.4		771.9	
Cost	USD													6969.6		6950.5		6739.5		6815.5	

#	unit	G08 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	3366		3516		3666		3816		3966		4116		4266		4416		4566		4716	
Self-weight	ton	17.078		17.823		18.589		19.355		20.120		20.866		21.632		22.397		23.163		23.909	
I	cm^4	1689918		2041192		2435429		2874621		3360741		3895749		4481593		5120209		5813528		6563471	
Wi	cm^3	36004		40965		46225		51779		57623		63753		70167		76862		83835		91083	
Ws	cm^3	60219		67651		75369		83365		91631		100165		108962		118020		127336		136910	
M self	kNm	412.5		430.5		449.0		467.5		486.0		504.0		522.5		541.0		559.5		577.5	
Mdesign	kNm	1344.6		1364.5		1384.5		1404.5		1424.4		1444.3		1464.1		1484.0		1503.8		1523.6	
Msdu	kNm	2690.7		2716.4		2741.9		2767.5		2792.9		2818.4		2843.7		2869.0		2894.2		2919.4	
Pi	kN	3730		3340		3010		2800		2620		2470		2330		2230		2120		2030	
e	cm	31.36		35.70		40.19		43.85		47.15		50.48		53.87		56.62		59.70		62.83	
Ap	mm^2	3640		3220		2800		2520		2380		2240		2100		2100		1960		1820	
n	strands	26		23		20		18		17		16		15		15		14		13	
σpi	MPa	1025		1037		1075		1111		1101		1103		1110		1062		1082		1115	
	%	61		62		64		67		66		66		66		64		65		67	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-8.34	-6.67	-8.13	-6.50	-7.84	-6.27	-7.39	-5.91	-6.88	-5.50	-6.45	-5.16	-6.06	-4.85	-5.65	-4.52	-5.30	-4.24	-5.01	-4.01
		43.57	34.86	38.61	30.89	34.38	27.50	31.05	24.84	28.04	22.44	25.56	20.45	23.35	18.68	21.48	17.18	19.74	15.79	18.31	14.65
σ at span	MPa	-1.49	15.65	-1.76	13.67	-1.88	12.10	-1.78	10.93	-1.57	10.04	-1.42	9.26	-1.26	8.59	-1.06	8.06	-0.90	7.57	-0.79	7.12
		32.11	-2.49	28.10	-2.42	24.67	-2.45	22.02	-2.28	19.61	-2.28	17.65	-2.21	15.90	-2.19	14.44	-2.13	13.07	-2.15	11.97	-2.08
Debonded	strands	19		17		15		13		12		11		10		10		9		8	
	X1(m)	7.0		7.5		8.0		8.0		7.0		6.5		6.0		5.5		5.5		5.0	
σ at support	MPa	-2.25		-2.12		-1.96		-2.05		-2.02		-2.01		-2.02		-1.88		-1.89		-1.93	
		11.73		10.07		8.60		8.62		8.25		7.99		7.78		7.16		7.05		7.04	
σ at X1	MPa	-2.11		-2.16		-2.12		-2.01		-2.05		-2.03		-2.03		-1.99		-1.79		-1.85	
		33.14		28.75		25.06		22.38		20.37		18.62		17.10		15.86		14.42		13.55	
Mcr	kNm	1352.5		1373.9		1391.8		1418.7		1437.9		1461.6		1482.2		1505.8		1523.3		1548.0	
Mu	kNm	2698.9		2773.6		2785.6		2774.3		2825.4		2854.5		2861.4		3018.7		2982.5		2924.3	
Cost/girder	USD	953.8		909.7		865.5		841.8		837.9		834.5		831.1		848.6		845.8		842.4	
Cost	USD	9303.6		8365.0		7940.3		7606.2		7403.2		7267.6		7141.1		7240.1		7167.5		7059.0	





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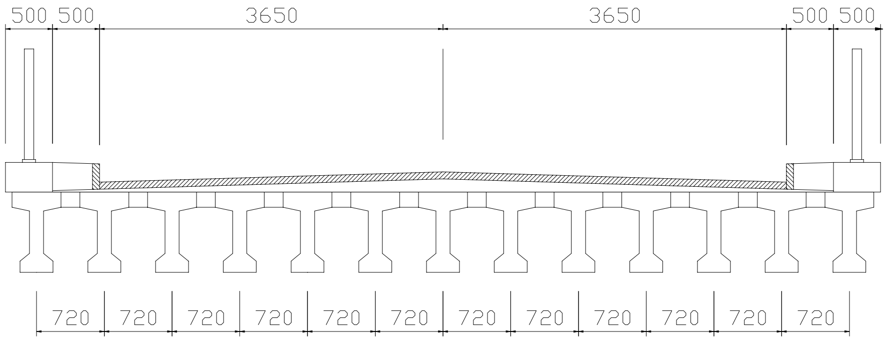
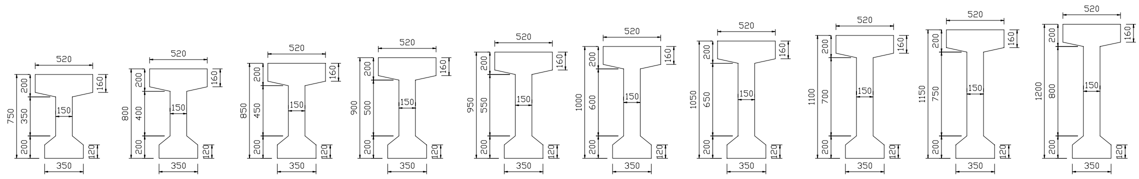
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2003	2078	2153	2228	2303	2378	2453	2528	2603	2678
Self-weight	ton	10.164	10.536	10.909	11.302	11.675	12.068	12.441	12.813	13.207	13.579
I	cm^4	1256787	1498146	1765369	2059405	2381201	2731703	3111857	3522605	3964892	4439660
Wi	cm^3	30847	34510	38319	42273	46368	50603	54976	59486	64132	68912
Ws	cm^3	36687	40947	45347	49885	54557	59362	64299	69366	74562	79886
M self	kNm	245.5	254.5	263.5	273.0	282.0	291.5	300.0	309.5	319.0	328.0
Mdesign	kNm	820.8	830.3	839.6	849.0	858.3	867.6	876.9	886.1	895.3	904.4
Msdu	kNm	1610.6	1622.6	1634.4	1646.3	1658.0	1669.6	1681.2	1692.7	1704.0	1715.3
Pi	kN	2030	1845	1710	1600	1505	1430	1350	1290	1230	1180
e	cm	31.74	35.34	38.57	41.44	44.35	46.98	49.94	52.55	55.57	58.18
Ap	mm^2	2100	1820	1680	1540	1400	1400	1260	1260	1120	1120
n	strands	15	13	12	11	10	10	9	9	8	8
σpi	MPa	967	1014	1018	1039	1075	1021	1071	1024	1098	1054
	%	58	61	61	62	64	61	64	61	66	63
σ limits	MPa	1.76 2.26	1.72 2.21	1.69 2.17	1.66 2.13	1.63 2.09	1.6 2.06	1.58 2.03	1.55 2	1.53 1.98	1.51 1.95
		24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24	24 24
σ at support	MPa	-7.43 -5.94	-7.04 -5.64	-6.60 -5.28	-6.11 -4.89	-5.70 -4.56	-5.30 -4.24	-4.98 -3.99	-4.67 -3.74	-4.44 -3.55	-4.19 -3.35
		31.02 24.82	27.77 22.22	25.15 20.12	22.87 18.29	20.93 16.74	19.29 15.43	17.77 14.21	16.50 13.20	15.38 12.31	14.37 11.49
σ at span	MPa	-0.74 16.43	-0.83 14.64	-0.79 13.23	-0.64 12.13	-0.53 11.17	-0.39 10.37	-0.32 9.65	-0.21 9.04	-0.16 8.45	-0.08 7.97
		23.06 -1.79	20.40 -1.84	18.28 -1.79	16.41 -1.79	14.85 -1.77	13.53 -1.71	12.31 -1.74	11.30 -1.70	10.41 -1.65	9.61 -1.63
Debonded	strands	12	10	9	9	8	7	7	7	6	6
	X1(m)	7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0	4.5	4.5
σ at support	MPa	-1.49	-1.63	-1.65	-1.11	-1.14	-1.59	-1.11	-1.04	-1.11	-1.05
		6.20	6.41	6.29	4.16	4.19	5.79	3.95	3.67	3.85	3.59
σ at X1	MPa	-1.34	-1.59	-1.50	-1.51	-1.58	-1.39	-1.48	-1.32	-1.46	-1.32
		23.78	21.30	19.12	17.44	16.08	14.70	13.67	12.60	11.91	11.05
Mcr	kNm	835.1	843.0	854.2	863.3	873.5	885.2	893.0	904.2	915.9	926.5
Mu	kNm	1651.5	1660.3	1713.2	1735.4	1706.2	1811.1	1743.1	1837.5	1735.3	1819.1
Cost/girder	USD	536.5	502.4	489.6	476.3	463.0	471.1	457.9	466.0	452.7	460.8
Cost	USD	8505.5	7852.3	7582.3	7340.4	7021.5	7057.9	6829.9	6943.3	6652.4	6765.8

#	unit	G14 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2003		2078		2153		2228		2303		2378		2453		2528		2603		2678	
Self-weight	ton	10.164		10.536		10.909		11.302		11.675		12.068		12.441		12.813		13.207		13.579	
I	cm^4	1256787		1498146		1765369		2059405		2381201		2731703		3111857		3522605		3964892		4439660	
Wi	cm^3	30847		34510		38319		42273		46368		50603		54976		59486		64132		68912	
Ws	cm^3	36687		40947		45347		49885		54557		59362		64299		69366		74562		79886	
M self	kNm	245.5		254.5		263.5		273.0		282.0		291.5		300.0		309.5		319.0		328.0	
Mdesign	kNm	820.8		830.3		839.6		849.0		858.3		867.6		876.9		886.1		895.3		904.4	
Msdu	kNm	1610.6		1622.6		1634.4		1646.3		1658.0		1669.6		1681.2		1692.7		1704.0		1715.3	
Pi	kN							1650		1555		1470		1395		1335		1280		1220	
e	cm							41.22		44.08		46.98		49.94		52.55		55.16		58.18	
Ap	mm^2							1680		1540		1400		1260		1260		1260		1120	
n	strands							12		11		10		9		9		9		8	
σpi	MPa							982		1010		1050		1107		1060		1016		1089	
	%							59		60		63		66		63		61		65	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa							-6.23	-4.98	-5.81	-4.65	-5.45	-4.36	-5.15	-4.12	-4.83	-3.87	-4.55	-3.64	-4.33	-3.46
								23.49	18.80	21.53	17.23	19.83	15.86	18.36	14.69	17.07	13.66	15.93	12.74	14.86	11.88
σ at span	MPa							-0.76	12.04	-0.64	11.08	-0.54	10.25	-0.48	9.52	-0.37	8.91	-0.27	8.37	-0.22	7.86
								17.04	-1.29	15.45	-1.28	14.07	-1.28	12.90	-1.26	11.87	-1.24	10.95	-1.22	10.10	-1.24
Debonded	strands							10		9		8		7		7		7		6	
	X1(m)							7.0		6.5		6.0		6.0		5.5		5.5		5.0	
σ at support	MPa							-1.04		-1.06		-1.09		-1.14		-1.07		-1.01		-1.08	
								3.92		3.92		3.97		4.08		3.79		3.54		3.71	
σ at X1	MPa							-1.25		-1.28		-1.33		-1.22		-1.27		-1.14		-1.25	
								17.62		16.20		14.99		13.77		12.92		11.96		11.29	
Mcr	kNm							864.6		874.3		883.8		894.1		904.9		915.4		923.2	
Mu	kNm							1653.4		1691.9		1717.2		1692.7		1787.1		1881.4		1779.4	
Cost/girder	USD							480.4		466.5		452.6		439.2		446.2		453.7		439.8	
Cost	USD							7607.2		7258.9		6924.5		6653.2		6709.2		6814.2		6507.9	





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<tr><td>h</td><td>cm</td><td colspan="2">75</td><td colspan="2">80</td><td colspan="2">85</td><td colspan="2">90</td><td colspan="2">95</td><td colspan="2">100</td><td colspan="2">105</td><td colspan="2">110</td><td colspan="2">115</td><td colspan="2">120</td></tr>
<tr><td>A</td><td>cm^2</td><td colspan="2">2111</td><td colspan="2">2186</td><td colspan="2">2261</td><td colspan="2">2336</td><td colspan="2">2411</td><td colspan="2">2486</td><td colspan="2">2561</td><td colspan="2">2636</td><td colspan="2">2711</td><td colspan="2">2786</td></tr>
<tr><td>Self-weight</td><td>ton</td><td colspan="2">10.702</td><td colspan="2">11.095</td><td colspan="2">11.468</td><td colspan="2">11.840</td><td colspan="2">12.234</td><td colspan="2">12.606</td><td colspan="2">12.979</td><td colspan="2">13.372</td><td colspan="2">13.745</td><td colspan="2">14.138</td></tr>
<tr><td>I</td><td>cm^4</td><td colspan="2">1324954</td><td colspan="2">1579060</td><td colspan="2">1860256</td><td colspan="2">2169502</td><td colspan="2">2507755</td><td colspan="2">2875970</td><td colspan="2">3275100</td><td colspan="2">3706095</td><td colspan="2">4169907</td><td colspan="2">4667483</td></tr>
<tr><td>Wi</td><td>cm^3</td><td colspan="2">31522</td><td colspan="2">35268</td><td colspan="2">39165</td><td colspan="2">43211</td><td colspan="2">47402</td><td colspan="2">51736</td><td colspan="2">56212</td><td colspan="2">60828</td><td colspan="2">65583</td><td colspan="2">70475</td></tr>
<tr><td>Ws</td><td>cm^3</td><td colspan="2">40191</td><td colspan="2">44826</td><td colspan="2">49604</td><td colspan="2">54520</td><td colspan="2">59573</td><td colspan="2">64758</td><td colspan="2">70075</td><td colspan="2">75523</td><td colspan="2">81099</td><td colspan="2">86803</td></tr>
<tr><td>M self</td><td>kNm</td><td colspan="2">258.5</td><td colspan="2">268.0</td><td colspan="2">277.0</td><td colspan="2">286.0</td><td colspan="2">295.5</td><td colspan="2">304.5</td><td colspan="2">313.5</td><td colspan="2">323.0</td><td colspan="2">332.0</td><td colspan="2">341.5</td></tr>
<tr><td>Mdesign</td><td>kNm</td><td colspan="2">894.3</td><td colspan="2">903.8</td><td colspan="2">913.2</td><td colspan="2">922.8</td><td colspan="2">932.3</td><td colspan="2">941.8</td><td colspan="2">951.2</td><td colspan="2">960.6</td><td colspan="2">970.0</td><td colspan="2">979.3</td></tr>
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<tr><td>Pi</td><td>kN</td><td colspan="2"></td><td colspan="2">2000</td><td colspan="2">1860</td><td colspan="2">1730</td><td colspan="2">1630</td><td colspan="2">1530</td><td colspan="2">1460</td><td colspan="2">1390</td><td colspan="2">1320</td><td colspan="2">1270</td></tr>
<tr><td>e</td><td>cm</td><td colspan="2"></td><td colspan="2">36.20</td><td colspan="2">39.42</td><td colspan="2">42.71</td><td colspan="2">45.63</td><td colspan="2">48.59</td><td colspan="2">51.26</td><td colspan="2">53.93</td><td colspan="2">56.92</td><td colspan="2">59.56</td></tr>
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<tr><td rowspan="2">σpi</td><td>MPa</td><td colspan="2"></td><td colspan="2">1020</td><td colspan="2">1022</td><td colspan="2">1030</td><td colspan="2">1058</td><td colspan="2">1093</td><td colspan="2">1043</td><td colspan="2">993</td><td colspan="2">1048</td><td colspan="2">1008</td></tr>
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<tr><td rowspan="2">σ limits</td><td rowspan="2">MPa</td><td>1.76</td><td>2.26</td><td>1.72</td><td>2.21</td><td>1.69</td><td>2.17</td><td>1.66</td><td>2.13</td><td>1.63</td><td>2.09</td><td>1.6</td><td>2.06</td><td>1.58</td><td>2.03</td><td>1.55</td><td>2</td><td>1.53</td><td>1.98</td><td>1.51</td><td>1.95</td></tr>
<tr><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td></td><td></td><td>-7.00</td><td>-5.60</td><td>-6.55</td><td>-5.24</td><td>-6.15</td><td>-4.92</td><td>-5.72</td><td>-4.58</td><td>-5.33</td><td>-4.26</td><td>-4.98</td><td>-3.98</td><td>-4.65</td><td>-3.72</td><td>-4.40</td><td>-3.52</td><td>-4.16</td><td>-3.32</td></tr>
<tr><td></td><td></td><td>29.68</td><td>23.74</td><td>26.95</td><td>21.56</td><td>24.51</td><td>19.60</td><td>22.45</td><td>17.96</td><td>20.52</td><td>16.42</td><td>19.01</td><td>15.21</td><td>17.60</td><td>14.08</td><td>16.33</td><td>13.06</td><td>15.29</td><td>12.23</td></tr>
<tr><td rowspan="2">σ at span</td><td rowspan="2">MPa</td><td></td><td></td><td>-1.02</td><td>14.56</td><td>-0.97</td><td>13.17</td><td>-0.90</td><td>12.01</td><td>-0.76</td><td>11.07</td><td>-0.62</td><td>10.28</td><td>-0.51</td><td>9.59</td><td>-0.38</td><td>9.00</td><td>-0.30</td><td>8.44</td><td>-0.22</td><td>7.96</td></tr>
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<tr><td rowspan="2">Debonded</td><td>strands</td><td colspan="2"></td><td colspan="2">11</td><td colspan="2">10</td><td colspan="2">9</td><td colspan="2">8</td><td colspan="2">7</td><td colspan="2">7</td><td colspan="2">7</td><td colspan="2">6</td><td colspan="2">6</td></tr>
<tr><td>X1(m)</td><td colspan="2"></td><td colspan="2">7.0</td><td colspan="2">6.5</td><td colspan="2">6.5</td><td colspan="2">6.0</td><td colspan="2">5.5</td><td colspan="2">5.5</td><td colspan="2">5.0</td><td colspan="2">5.0</td><td colspan="2">4.5</td></tr>
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<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2"></td><td colspan="2">-1.56</td><td colspan="2">-1.65</td><td colspan="2">-1.54</td><td colspan="2">-1.56</td><td colspan="2">-1.58</td><td colspan="2">-1.41</td><td colspan="2">-1.45</td><td colspan="2">-1.33</td><td colspan="2">-1.41</td></tr>
<tr><td colspan="2"></td><td colspan="2">22.76</td><td colspan="2">20.74</td><td colspan="2">18.70</td><td colspan="2">17.21</td><td colspan="2">15.83</td><td colspan="2">14.57</td><td colspan="2">13.61</td><td colspan="2">12.53</td><td colspan="2">11.91</td></tr>
<tr><td>Mcr</td><td>kNm</td><td colspan="2"></td><td colspan="2">915.2</td><td colspan="2">929.2</td><td colspan="2">939.1</td><td colspan="2">950.6</td><td colspan="2">956.1</td><td colspan="2">969.2</td><td colspan="2">978.1</td><td colspan="2">986.1</td><td colspan="2">999.6</td></tr>
<tr><td>Mu</td><td>kNm</td><td colspan="2"></td><td colspan="2">1794.3</td><td colspan="2">1857.8</td><td colspan="2">1897.7</td><td colspan="2">1874.7</td><td colspan="2">1827.1</td><td colspan="2">1931.9</td><td colspan="2">2036.8</td><td colspan="2">1944.8</td><td colspan="2">2039.1</td></tr>
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<tr><td>Cost</td><td>USD</td><td colspan="2"></td><td colspan="2">7870.5</td><td colspan="2">7548.3</td><td colspan="2">7297.7</td><td colspan="2">6995.0</td><td colspan="2">6705.4</td><td colspan="2">6810.7</td><td colspan="2">6870.5</td><td colspan="2">6639.3</td><td colspan="2">6705.6</td></tr>
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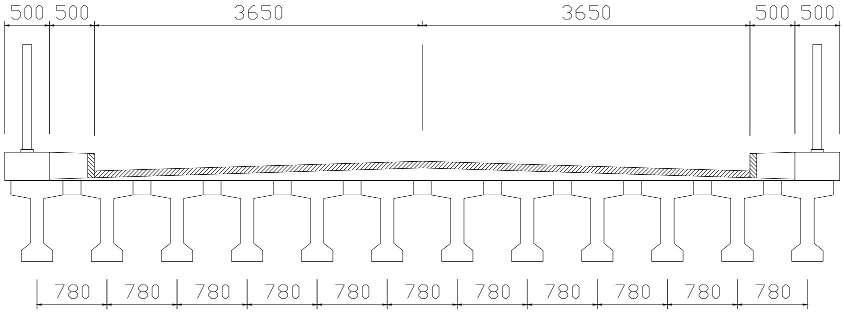
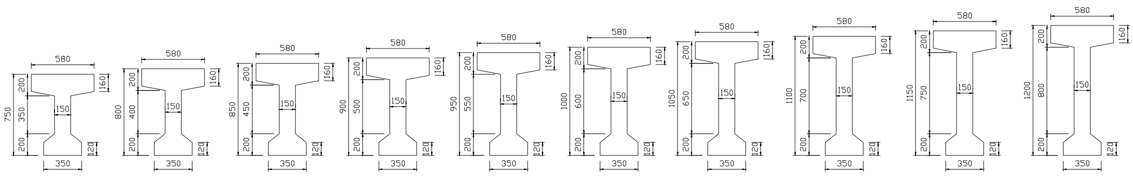
#	unit	G13 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2111		2186		2261		2336		2411		2486		2561		2636		2711		2786	
Self-weight	ton	10.702		11.095		11.468		11.840		12.234		12.606		12.979		13.372		13.745		14.138	
I	cm^4	1324954		1579060		1860256		2169502		2507755		2875970		3275100		3706095		4169907		4667483	
Wi	cm^3	31522		35268		39165		43211		47402		51736		56212		60828		65583		70475	
Ws	cm^3	40191		44826		49604		54520		59573		64758		70075		75523		81099		86803	
M self	kNm	258.5		268.0		277.0		286.0		295.5		304.5		313.5		323.0		332.0		341.5	
Mdesign	kNm	894.3		903.8		913.2		922.8		932.3		941.8		951.2		960.6		970.0		979.3	
Msdu	kNm	1768.9		1781.0		1792.9		1805.0		1816.8		1828.7		1840.4		1852.1		1863.7		1875.2	
Pi	kN									1670		1580		1490		1430		1370		1315	
eccentricity	cm									45.40		48.32		51.26		53.93		56.92		59.56	
Ap	mm^2									1680		1540		1400		1400		1260		1260	
n	strands									12		11		10		10		9		9	
σpi	MPa									994		1026		1064		1021		1087		1044	
	%									60		61		64		61		65		62	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa									-5.80	-4.64	-5.43	-4.35	-5.08	-4.07	-4.79	-3.83	-4.56	-3.65	-4.30	-3.44
										22.92	18.34	21.11	16.89	19.41	15.52	18.10	14.48	16.94	13.56	15.83	12.67
σ at span	MPa									-0.84	11.01	-0.73	10.20	-0.61	9.51	-0.51	8.89	-0.47	8.31	-0.37	7.84
										16.69	-1.33	15.23	-1.31	13.83	-1.40	12.79	-1.31	11.88	-1.23	10.99	-1.23
Debonded	strands									10		9		8		8		7		7	
	X1(m)									7.0		6.5		6.5		6.0		6.0		5.5	
σ at support	MPa									-0.97		-0.99		-1.02		-0.96		-1.01		-0.96	
										3.82		3.84		3.88		3.62		3.77		3.52	
σ at X1	MPa									-1.29		-1.31		-1.16		-1.19		-1.12		-1.17	
										17.25		15.95		14.51		13.64		12.69		11.97	
Mcr	kNm									946.4		956.7		961.3		975.4		989.4		999.2	
Mu	kNm									1860.5		1899.7		1877.0		1981.8		1900.3		1994.7	
Cost/girder	USD									498.7		484.8		471.4		478.4		465.0		472.0	
Cost	USD									7301.7		6978.3		6719.8		6765.3		6513.4		6565.4	

#	unit	G13 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2111		2186		2261		2336		2411		2486		2561		2636		2711		2786	
Self-weight	ton	10.702		11.095		11.468		11.840		12.234		12.606		12.979		13.372		13.745		14.138	
I	cm^4	1324954		1579060		1860256		2169502		2507755		2875970		3275100		3706095		4169907		4667483	
Wi	cm^3	31522		35268		39165		43211		47402		51736		56212		60828		65583		70475	
Ws	cm^3	40191		44826		49604		54520		59573		64758		70075		75523		81099		86803	
M self	kNm	258.5		268.0		277.0		286.0		295.5		304.5		313.5		323.0		332.0		341.5	
Mdesign	kNm	894.3		903.8		913.2		922.8		932.3		941.8		951.2		960.6		970.0		979.3	
Msdu	kNm	1768.9		1781.0		1792.9		1805.0		1816.8		1828.7		1840.4		1852.1		1863.7		1875.2	
Pi	kN	2155		1965		1810		1690		1585		1495		1420		1345		1285		1230	
e	cm	32.66		36.20		39.42		42.71		45.63		48.59		51.26		54.26		56.92		59.56	
Ap	mm^2	2240		1960		1820		1680		1540		1400		1400		1260		1260		1260	
n	strands	16		14		13		12		11		10		10		9		9		9	
σpi	MPa	962		1003		995		1006		1029		1068		1014		1067		1020		976	
	%	58		60		60		60		62		64		61		64		61		58	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-7.30	-5.84	-6.88	-5.50	-6.38	-5.10	-6.00	-4.80	-5.57	-4.45	-5.20	-4.16	-4.84	-3.87	-4.56	-3.65	-4.28	-3.42	-4.02	-3.22
		32.54	26.03	29.16	23.33	26.22	20.98	23.94	19.15	21.83	17.47	20.05	16.04	18.49	14.79	17.10	13.68	15.89	12.71	14.81	11.85
σ at span	MPa	-0.87	16.41	-0.90	14.66	-0.79	13.31	-0.76	12.12	-0.61	11.20	-0.50	10.38	-0.37	9.70	-0.28	9.07	-0.19	8.54	-0.09	8.06
		24.34	-2.34	21.56	-2.30	19.15	-2.34	17.32	-2.21	15.60	-2.20	14.17	-2.16	12.92	-2.13	11.79	-2.11	10.83	-2.08	9.96	-2.05
Debonded	strands	12		10		9		8		7		7		6		6		5		5	
	X1(m)	5.5		5.5		5.5		5.0		5.0		4.5		4.0		4.0		3.5		3.5	
σ at support	MPa	-1.83		-1.97		-1.96		-2.00		-2.02		-1.56		-1.94		-1.52		-1.90		-1.79	
		8.13		8.33		8.07		7.98		7.94		6.02		7.40		5.70		7.06		6.58	
σ at X1	MPa	-2.17		-2.11		-1.93		-2.07		-1.85		-1.92		-1.98		-1.82		-1.91		-1.75	
		26.00		23.10		20.58		18.97		17.16		15.95		14.92		13.70		12.97		12.01	
Mcr	kNm	905.9		916.3		923.6		938.1		947.2		958.3		969.0		978.7		989.8		1000.5	
Mu	kNm	1831.9		1828.5		1884.1		1924.2		1903.0		1850.5		1955.4		1869.4		1963.8		2058.1	
Cost/girder	USD	592.9		560.2		548.3		535.9		524.0		511.6		520.1		508.2		516.7		525.7	
Cost	USD	8494.4		7925.5		7699.5		7421.6		7202.1		7002.2		7021.7		6867.2		6899.7		7016.7	

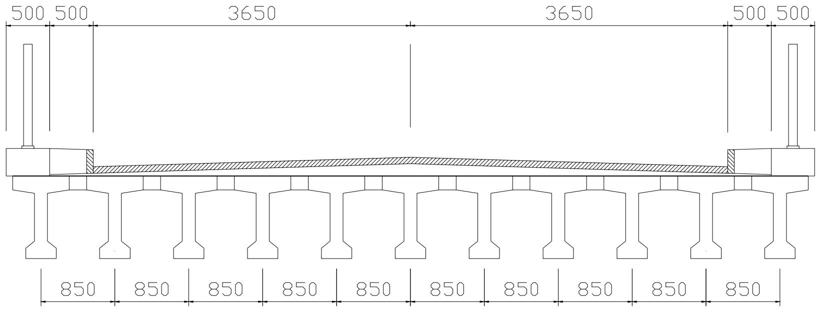


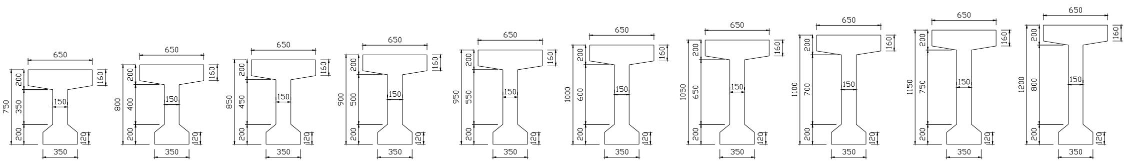


#	unit	G12 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2219		2294		2369		2444		2519		2594		2669		2744		2819		2894	
Self-weight	ton	11.261		11.633		12.006		12.399		12.772		13.165		13.538		13.910		14.304		14.676	
I	cm^4	1386776		1652637		1946764		2270133		2623713		3008472		3425373		3875377		4359443		4878525	
Wi	cm^3	32103		35922		39897		44023		48300		52723		57291		62003		66856		71850	
Ws	cm^3	43606		48616		53771		59067		64499		70065		75764		81592		87550		93635	
M self	kNm	272.0		281.0		290.0		299.5		308.5		318.0		327.0		336.0		345.5		354.5	
Mdesign	kNm	964.6		974.1		983.7		993.2		1002.7		1012.2		1021.7		1031.1		1040.5		1049.9	
Msdu	kNm	1915.0		1927.1		1939.1		1951.1		1963.0		1974.8		1986.6		1998.3		2009.9		2021.4	
Pi	kN			2150		2000		1860		1740		1640		1560		1480		1410		1350	
e	cm			36.63		40.22		43.49		46.82		49.79		52.52		55.50		58.21		61.23	
Ap	mm^2			2240		1960		1820		1680		1540		1540		1400		1400		1260	
n	strands			16		14		13		12		11		11		10		10		9	
σpi	MPa			960		1020		1022		1036		1065		1013		1057		1007		1071	
	%			57		61		61		62		64		61		63		60		64	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa			-6.83	-5.46	-6.52	-5.21	-6.08	-4.87	-5.72	-4.58	-5.33	-4.27	-4.97	-3.98	-4.67	-3.74	-4.37	-3.50	-4.16	-3.33
				31.30	25.04	28.60	22.88	25.99	20.79	23.77	19.02	21.81	17.45	20.15	16.12	18.64	14.91	17.28	13.82	16.17	12.94
σ at span	MPa			-1.05	14.58	-1.12	13.08	-1.01	11.95	-0.94	10.97	-0.79	10.18	-0.65	9.51	-0.56	8.90	-0.43	8.39	-0.38	7.88
				23.47	-2.08	21.34	-1.77	19.18	-1.77	17.39	-1.74	15.78	-1.75	14.44	-1.72	13.22	-1.72	12.11	-1.74	11.24	-1.68
Debonded	strands			12		11		10		9		8		8		7		7		6	
	X1(m)			7.5		7.0		6.5		6.5		6.0		5.5		5.5		5.0		5.0	
σ at support	MPa			-1.71		-1.40		-1.40		-1.43		-1.45		-1.36		-1.40		-1.31		-1.39	
				7.82		6.13		6.00		5.94		5.95		5.49		5.59		5.18		5.39	
σ at X1	MPa			-1.41		-1.61		-1.64		-1.53		-1.52		-1.53		-1.39		-1.41		-1.32	
				23.96		21.99		20.02		18.17		16.74		15.59		14.32		13.40		12.47	
Mcr	kNm			978.7		999.4		1008.9		1019.8		1028.6		1039.7		1048.8		1056.2		1069.6	
Mu	kNm			2005.7		2001.2		2045.8		2042.9		2005.4		2120.7		2049.5		2154.3		2049.4	
Cost/girder	USD			589.3		555.2		541.9		529.1		515.8		523.4		510.7		518.3		505.5	
Cost	USD			8062.2		7502.2		7204.9		6973.5		6694.1		6743.3		6523.9		6579.1		6365.8	

#	unit	G12 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2219		2294		2369		2444		2519		2594		2669		2744		2819		2894	
Self-weight	ton	11.261		11.633		12.006		12.399		12.772		13.165		13.538		13.910		14.304		14.676	
I	cm^4	1386776		1652637		1946764		2270133		2623713		3008472		3425373		3875377		4359443		4878525	
Wi	cm^3	32103		35922		39897		44023		48300		52723		57291		62003		66856		71850	
Ws	cm^3	43606		48616		53771		59067		64499		70065		75764		81592		87550		93635	
M self	kNm	272.0		281.0		290.0		299.5		308.5		318.0		327.0		336.0		345.5		354.5	
Mdesign	kNm	964.6		974.1		983.7		993.2		1002.7		1012.2		1021.7		1031.1		1040.5		1049.9	
Msdu	kNm	1915.0		1927.1		1939.1		1951.1		1963.0		1974.8		1986.6		1998.3		2009.9		2021.4	
Pi	kN									1775		1690		1600		1530		1460		1400	
e	cm									46.24		49.56		52.52		55.50		58.21		60.90	
Ap	mm^2									1820		1680		1540		1400		1400		1400	
n	strands									13		12		11		10		10		10	
σpi	MPa									975		1006		1039		1093		1043		1000	
	%									58		60		62		65		62		60	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa									-5.68	-4.54	-5.44	-4.35	-5.10	-4.08	-4.83	-3.87	-4.53	-3.62	-4.27	-3.41
										24.04	19.23	22.40	17.92	20.66	16.53	19.27	15.42	17.89	14.31	16.70	13.36
σ at span	MPa									-0.90	11.00	-0.90	10.10	-0.78	9.41	-0.71	8.77	-0.58	8.26	-0.48	7.80
										17.65	-1.53	16.37	-1.28	14.95	-1.30	13.85	-1.21	12.72	-1.25	11.77	-1.25
Debonded	strands									10		10		9		8		8		8	
	X1(m)									8.0		7.0		6.5		6.5		6.0		5.5	
σ at support	MPa									-1.31		-0.91		-0.93		-0.97		-0.91		-0.85	
										5.55		3.73		3.76		3.85		3.58		3.34	
σ at X1	MPa									-1.09		-1.31		-1.31		-1.22		-1.21		-1.25	
										17.91		16.91		15.65		14.52		13.55		12.77	
Mcr	kNm									1007.5		1029.3		1037.3		1052.2		1059.3		1068.8	
Mu	kNm									2019.7		2080.6		2061.1		2000.2		2105.1		2209.9	
Cost/girder	USD									531.4		517.0		503.1		489.7		496.7		503.7	
Cost	USD									7240.2		6959.7		6661.1		6422.5		6464.5		6506.5	

#	unit	G12 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2219		2294		2369		2444		2519		2594		2669		2744		2819		2894	
Self-weight	ton	11.261		11.633		12.006		12.399		12.772		13.165		13.538		13.910		14.304		14.676	
I	cm^4	1386776		1652637		1946764		2270133		2623713		3008472		3425373		3875377		4359443		4878525	
Wi	cm^3	32103		35922		39897		44023		48300		52723		57291		62003		66856		71850	
Ws	cm^3	43606		48616		53771		59067		64499		70065		75764		81592		87550		93635	
M self	kNm	272.0		281.0		290.0		299.5		308.5		318.0		327.0		336.0		345.5		354.5	
Mdesign	kNm	964.6		974.1		983.7		993.2		1002.7		1012.2		1021.7		1031.1		1040.5		1049.9	
Msdu	kNm	1915.0		1927.1		1939.1		1951.1		1963.0		1974.8		1986.6		1998.3		2009.9		2021.4	
Pi	kN	2345		2130		1960		1820		1700		1600		1520		1440		1375		1310	
e	cm	32.90		36.63		40.22		43.49		46.82		49.79		52.52		55.50		58.21		61.23	
Ap	mm^2	2380		2240		1960		1820		1680		1540		1540		1400		1400		1260	
n	strands	17		16		14		13		12		11		11		10		10		9	
σpi	MPa	985		951		1000		1000		1012		1039		987		1029		982		1040	
	%	59		57		60		60		61		62		59		62		59		62	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-7.12	-5.70	-6.76	-5.41	-6.39	-5.11	-5.95	-4.76	-5.59	-4.47	-5.20	-4.16	-4.84	-3.87	-4.55	-3.64	-4.26	-3.41	-4.04	-3.23
		34.60	27.68	31.00	24.80	28.03	22.43	25.43	20.34	23.23	18.58	21.28	17.02	19.63	15.70	18.14	14.51	16.85	13.48	15.69	12.55
σ at span	MPa	-0.89	16.42	-0.98	14.63	-0.99	13.18	-0.88	12.05	-0.81	11.07	-0.66	10.29	-0.53	9.61	-0.43	9.00	-0.32	8.47	-0.25	7.98
		26.13	-2.37	23.18	-2.31	20.76	-2.23	18.62	-2.22	16.84	-2.18	15.25	-2.18	13.92	-2.13	12.72	-2.12	11.68	-2.08	10.76	-2.06
Debonded	strands	12		11		10		9		8		7		7		6		6		5	
	X1(m)	5.5		5.5		5.5		5.5		5.0		4.5		4.5		4.0		4.0		3.5	
σ at support	MPa	-2.10		-2.11		-1.82		-1.83		-1.86		-1.89		-1.76		-1.82		-1.71		-1.80	
		10.18		9.69		8.01		7.82		7.74		7.74		7.14		7.26		6.74		6.97	
σ at X1	MPa	-2.15		-2.15		-2.09		-1.91		-2.00		-2.04		-1.83		-1.91		-1.74		-1.85	
		27.84		24.77		22.24		20.00		18.44		17.07		15.65		14.67		13.54		12.84	
Mcr	kNm	975.6		986.3		998.6		1008.2		1019.1		1028.2		1039.7		1049.1		1060.2		1070.7	
Mu	kNm	1935.7		2046.8		2028.5		2075.5		2073.2		2030.8		2146.1		2070.5		2175.3		2066.5	
Cost/girder	USD	626.8		614.9		582.1		570.2		557.9		545.5		554.5		542.1		551.1		538.7	
Cost	USD	8313.1		8038.5		7579.4		7370.8		7114.2		6869.7		6977.7		6745.1		6853.1		6632.5	





#	unit	G11 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2345		2420		2495		2570		2645		2720		2795		2870		2945		3020	
Self-weight	ton	11.903		12.275		12.648		13.041		13.414		13.786		14.180		14.552		14.945		15.318	
I	cm^4	1452052		1730514		2038552		2377163		2747338		3150059		3586306		4057055		4563274		5105933	
Wi	cm^3	32688		36581		40635		44846		49210		53726		58390		63202		68160		73261	
Ws	cm^3	47485		52930		58524		64261		70137		76148		82292		88566		94969		101500	
M self	kNm	287.5		296.5		305.5		315.0		324.0		333.0		342.5		351.5		361.0		370.0	
Mdesign	kNm	1037.1		1046.7		1056.3		1065.8		1075.4		1084.9		1094.4		1103.8		1113.2		1122.6	
Msdu	kNm	2063.0		2075.2		2087.2		2099.2		2111.1		2123.0		2134.8		2146.5		2158.1		2169.6	
Pi	kN					2150		1990		1860		1750		1655		1580		1500		1440	
e	cm					41.17		44.44		47.75		51.13		54.15		56.92		59.95		62.70	
Ap	mm^2					2100		1960		1820		1680		1540		1540		1400		1400	
n	strands					15		14		13		12		11		11		10		10	
σpi	MPa					1024		1015		1022		1042		1075		1026		1071		1029	
	%					61		61		61		62		64		61		64		62	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa					-6.51	-5.21	-6.02	-4.81	-5.63	-4.50	-5.32	-4.25	-4.97	-3.98	-4.65	-3.72	-4.38	-3.50	-4.13	-3.30
						30.40	24.32	27.46	21.97	25.08	20.06	23.09	18.47	21.27	17.02	19.73	15.79	18.29	14.63	17.09	13.67
σ at span	MPa					-1.29	12.84	-1.12	11.77	-1.01	10.83	-0.94	9.99	-0.81	9.32	-0.68	8.74	-0.57	8.22	-0.48	7.76
						22.88	-1.67	20.44	-1.80	18.50	-1.79	16.89	-1.72	15.40	-1.73	14.17	-1.68	12.99	-1.70	12.04	-1.65
Debonded	strands					12		11		10		9		8		8		7		7	
	X1(m)					7.5		7.0		6.5		6.5		6.0		5.5		5.0		5.0	
σ at support	MPa					-1.30		-1.29		-1.30		-1.33		-1.36		-1.27		-1.31		-1.24	
						6.08		5.88		5.79		5.77		5.80		5.38		5.49		5.13	
σ at X1	MPa					-1.61		-1.56		-1.58		-1.48		-1.47		-1.48		-1.52		-1.39	
						23.35		21.07		19.30		17.65		16.34		15.30		14.31		13.30	
Mcr	kNm					1076.3		1080.8		1090.4		1103.1		1112.1		1124.4		1131.8		1144.7	
Mu	kNm					2152.2		2197.3		2203.2		2185.8		2135.1		2250.4		2166.2		2271.0	
Cost/girder	USD					590.2		576.9		563.6		550.8		537.6		545.2		531.9		540.0	
Cost	USD					7399.4		7115.8		6843.2		6631.2		6375.1		6420.2		6180.6		6269.7	

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<tr><td colspan="2">10.20</td><td colspan="2">10.29</td><td colspan="2">9.90</td><td colspan="2">9.61</td><td colspan="2">7.55</td><td colspan="2">7.52</td><td colspan="2">7.55</td><td colspan="2">6.99</td><td colspan="2">7.12</td><td colspan="2">6.65</td></tr>
<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2">-2.11</td><td colspan="2">-2.18</td><td colspan="2">-1.97</td><td colspan="2">-1.99</td><td colspan="2">-2.05</td><td colspan="2">-1.92</td><td colspan="2">-1.95</td><td colspan="2">-1.99</td><td colspan="2">-1.83</td><td colspan="2">-1.91</td></tr>
<tr><td colspan="2">29.32</td><td colspan="2">26.11</td><td colspan="2">23.38</td><td colspan="2">21.31</td><td colspan="2">19.60</td><td colspan="2">17.91</td><td colspan="2">16.66</td><td colspan="2">15.68</td><td colspan="2">14.41</td><td colspan="2">13.70</td></tr>
<tr><td>Mcr</td><td>kNm</td><td colspan="2">1048.5</td><td colspan="2">1060.4</td><td colspan="2">1071.1</td><td colspan="2">1080.3</td><td colspan="2">1090.0</td><td colspan="2">1102.9</td><td colspan="2">1112.2</td><td colspan="2">1124.9</td><td colspan="2">1132.7</td><td colspan="2">1146.0</td></tr>
<tr><td>Mu</td><td>kNm</td><td colspan="2">2064.9</td><td colspan="2">2100.9</td><td colspan="2">2178.9</td><td colspan="2">2231.6</td><td colspan="2">2234.9</td><td colspan="2">2212.8</td><td colspan="2">2157.7</td><td colspan="2">2273.1</td><td colspan="2">2184.9</td><td colspan="2">2289.8</td></tr>
<tr><td>Cost/girder</td><td>USD</td><td colspan="2">663.3</td><td colspan="2">630.5</td><td colspan="2">618.6</td><td colspan="2">606.2</td><td colspan="2">593.9</td><td colspan="2">582.0</td><td colspan="2">569.6</td><td colspan="2">578.1</td><td colspan="2">566.2</td><td colspan="2">574.7</td></tr>
<tr><td>Cost</td><td>USD</td><td colspan="2">8243.8</td><td colspan="2">7595.5</td><td colspan="2">7398.8</td><td colspan="2">7152.6</td><td colspan="2">6972.4</td><td colspan="2">6786.7</td><td colspan="2">6562.5</td><td colspan="2">6623.0</td><td colspan="2">6448.3</td><td colspan="2">6514.3</td></tr>
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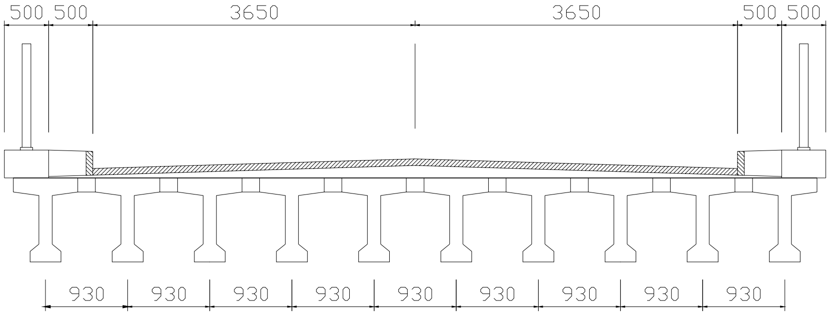
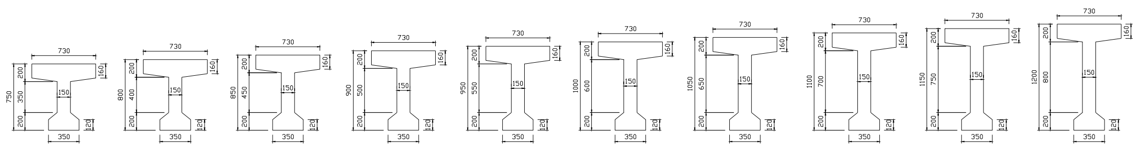
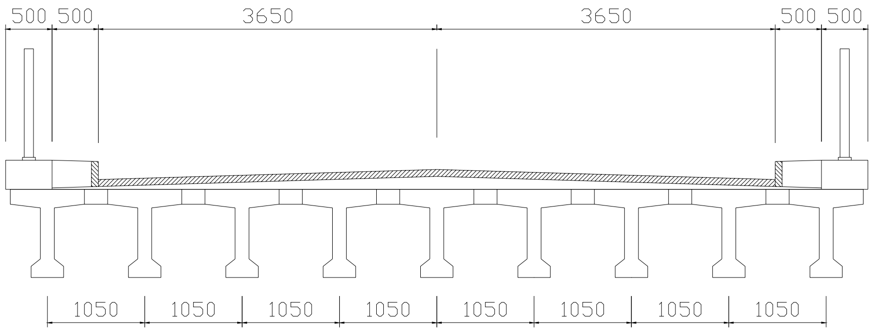


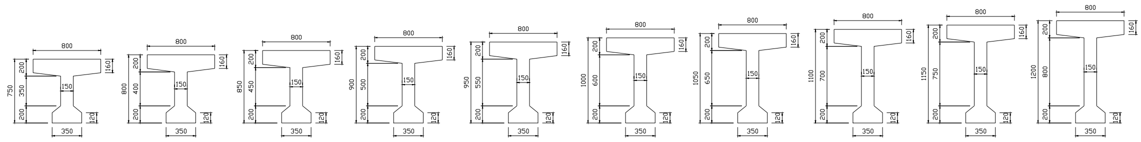


#	unit	G10 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2489		2564		2639		2714		2789		2864		2939		3014		3089		3164	
Self-weight	ton	12.627		13.000		13.393		13.766		14.138		14.531		14.904		15.277		15.670		16.043	
I	cm^4	1518994		1810563		2133127		2487711		2875331		3296993		3753699		4246443		4776212		5343990	
Wi	cm^3	33262		37228		41360		45654		50106		54715		59477		64390		69453		74664	
Ws	cm^3	51785		57725		63818		70059		76441		82960		89613		96397		103311		110353	
M self	kNm	305.0		314.0		323.5		332.5		341.5		351.0		360.0		369.0		378.5		387.5	
Mdesign	kNm	1121.7		1131.4		1141.0		1150.6		1160.2		1169.7		1179.2		1188.7		1198.1		1207.6	
Msdu	kNm	2236.9		2249.1		2261.2		2273.2		2285.1		2297.0		2308.8		2320.5		2332.1		2343.6	
Pi	kN					2296		2145		2005		1885		1775		1690		1610		1540	
e	cm					41.57		45.49		48.81		52.18		55.61		58.45		61.50		64.30	
Ap	mm^2					2240		2100		1960		1820		1680		1680		1540		1540	
n	strands					16		15		14		13		12		12		11		11	
σpi	MPa					1025		1021		1023		1036		1057		1006		1045		1000	
	%					61		61		61		62		63		60		63		60	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa					-6.26	-5.00	-6.02	-4.82	-5.61	-4.49	-5.27	-4.22	-4.98	-3.98	-4.64	-3.71	-4.37	-3.50	-4.11	-3.28
						31.78	25.42	29.28	23.42	26.72	21.38	24.56	19.65	22.64	18.11	20.95	16.76	19.47	15.57	18.13	14.50
σ at span	MPa					-1.19	12.87	-1.28	11.60	-1.15	10.69	-1.04	9.88	-0.96	9.18	-0.81	8.62	-0.71	8.10	-0.59	7.66
						23.96	-2.17	21.99	-1.78	19.90	-1.78	18.14	-1.73	16.58	-1.72	15.22	-1.70	14.02	-1.68	12.94	-1.67
Debonded	strands					12		11		10		10		9		8		8		7	
	X1(m)					9.5		7.5		7.0		6.5		6.5		6.0		5.5		5.0	
σ at support	MPa					-1.56		-1.61		-1.60		-1.22		-1.24		-1.55		-1.19		-1.49	
						7.94		7.81		7.63		5.67		5.66		6.98		5.31		6.59	
σ at X1	MPa					-1.20		-1.57		-1.55		-1.56		-1.45		-1.42		-1.45		-1.47	
						23.97		22.45		20.52		18.93		17.32		16.13		15.12		14.24	
Mcr	kNm					1141.1		1166.5		1176.0		1187.7		1197.8		1208.0		1218.9		1228.5	
Mu	kNm					2280.5		2350.6		2365.5		2357.7		2327.1		2453.0		2378.7		2494.0	
Cost/girder	USD					628.6		613.8		600.5		587.3		574.5		582.1		568.8		576.4	
Cost	USD					7331.1		6888.3		6635.5		6457.7		6264.8		6240.8		6073.0		6064.0	

#	unit	G10 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2489		2564		2639		2714		2789		2864		2939		3014		3089		3164	
Self-weight	ton	12.627		13.000		13.393		13.766		14.138		14.531		14.904		15.277		15.670		16.043	
I	cm^4	1518994		1810563		2133127		2487711		2875331		3296993		3753699		4246443		4776212		5343990	
Wi	cm^3	33262		37228		41360		45654		50106		54715		59477		64390		69453		74664	
Ws	cm^3	51785		57725		63818		70059		76441		82960		89613		96397		103311		110353	
M self	kNm	305.0		314.0		323.5		332.5		341.5		351.0		360.0		369.0		378.5		387.5	
Mdesign	kNm	1121.7		1131.4		1141.0		1150.6		1160.2		1169.7		1179.2		1188.7		1198.1		1207.6	
Msdu	kNm	2236.9		2249.1		2261.2		2273.2		2285.1		2297.0		2308.8		2320.5		2332.1		2343.6	
Pi	kN													1820		1735		1655		1590	
e	cm													55.04		58.45		61.50		64.30	
Ap	mm^2													1820		1680		1540		1540	
n	strands													13		12		11		11	
σpi	MPa													1000		1033		1075		1032	
	%													60		62		64		62	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa													-4.99	-3.99	-4.76	-3.81	-4.49	-3.60	-4.24	-3.39
														23.03	18.43	21.51	17.20	20.01	16.01	18.72	14.97
σ at span	MPa													-0.97	9.17	-0.94	8.52	-0.83	8.00	-0.73	7.55
														16.98	-1.40	15.78	-1.26	14.56	-1.24	13.53	-1.20
Debonded	strands													10		9		8		8	
	X1(m)													7.5		7.0		6.5		6.5	
σ at support	MPa													-1.15		-1.19		-1.23		-1.16	
														5.32		5.38		5.46		5.10	
σ at X1	MPa													-1.22		-1.28		-1.28		-1.16	
														17.36		16.29		15.23		14.16	
Mcr	kNm													1189.8		1207.8		1218.3		1230.9	
Mu	kNm													2427.9		2396.6		2331.4		2446.7	
Cost/girder	USD													572.9		559.0		545.1		552.6	
Cost	USD													6403.5		6149.7		5905.9		5980.9	

#	unit	G10 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2489		2564		2639		2714		2789		2864		2939		3014		3089		3164	
Self-weight	ton	12.627		13.000		13.393		13.766		14.138		14.531		14.904		15.277		15.670		16.043	
I	cm^4	1518994		1810563		2133127		2487711		2875331		3296993		3753699		4246443		4776212		5343990	
Wi	cm^3	33262		37228		41360		45654		50106		54715		59477		64390		69453		74664	
Ws	cm^3	51785		57725		63818		70059		76441		82960		89613		96397		103311		110353	
M self	kNm	305.0		314.0		323.5		332.5		341.5		351.0		360.0		369.0		378.5		387.5	
Mdesign	kNm	1121.7		1131.4		1141.0		1150.6		1160.2		1169.7		1179.2		1188.7		1198.1		1207.6	
Msdu	kNm	2236.9		2249.1		2261.2		2273.2		2285.1		2297.0		2308.8		2320.5		2332.1		2343.6	
Pi	kN	2870		2485		2296		2105		1965		1845		1735		1660		1570		1500	
e	cm	33.67		38.08		41.57		45.49		48.81		52.18		55.61		58.45		61.50		64.30	
Ap	mm^2	2800		2520		2240		2100		1960		1820		1680		1680		1540		1540	
n	strands	20		18		16		15		14		13		12		12		11		11	
σpi	MPa	1025		986		1025		1002		1003		1014		1033		988		1019		974	
	%	61		59		61		60		60		61		62		59		61		58	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-7.13	-5.70	-6.70	-5.36	-6.26	-5.00	-5.91	-4.73	-5.50	-4.40	-5.16	-4.13	-4.86	-3.89	-4.56	-3.65	-4.26	-3.41	-4.00	-3.20
		40.58	32.47	35.11	28.09	31.78	25.42	28.73	22.98	26.19	20.95	24.04	19.23	22.13	17.70	20.58	16.46	18.98	15.19	17.66	14.13
σ at span	MPa	-1.24	15.96	-1.26	14.24	-1.19	12.87	-1.17	11.69	-1.03	10.78	-0.93	9.97	-0.85	9.27	-0.73	8.69	-0.60	8.19	-0.49	7.74
		31.41	-1.26	26.68	-2.30	23.96	-2.17	21.45	-2.22	19.37	-2.20	17.62	-2.15	16.07	-2.13	14.85	-2.00	13.53	-2.06	12.47	-2.05
Debonded	strands	14		13		11		10		9		8		7		7		6		6	
	X1(m)	6.0		6.0		6.0		5.5		5.5		5.0		5.0		4.5		4.0		4.0	
σ at support	MPa	-2.14		-1.86		-1.95		-1.97		-1.96		-1.99		-2.03		-1.90		-1.94		-1.82	
		12.17		9.75		9.93		9.58		9.35		9.25		9.22		8.57		8.63		8.03	
σ at X1	MPa	-2.18		-2.13		-2.00		-2.13		-1.94		-1.99		-1.85		-1.89		-1.92		-1.75	
		32.88		28.03		25.21		22.92		20.75		19.23		17.59		16.58		15.50		14.34	
Mcr	kNm	1170.0		1144.5		1159.2		1166.2		1175.9		1187.8		1198.1		1215.1		1220.0		1230.2	
Mu	kNm	2241.4		2313.2		2314.4		2387.3		2398.2		2385.9		2351.2		2477.0		2398.9		2514.3	
Cost/girder	USD	722.3		689.5		656.8		644.4		632.5		620.1		608.3		616.8		604.4		613.4	
Cost	USD	8255.0		7615.4		7167.8		6939.0		6765.1		6551.3		6382.5		6437.5		6243.7		6333.7	





<table>
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<tr><td>A</td><td>cm^2</td><td colspan="2">2615</td><td colspan="2">2690</td><td colspan="2">2765</td><td colspan="2">2840</td><td colspan="2">2915</td><td colspan="2">2990</td><td colspan="2">3065</td><td colspan="2">3140</td><td colspan="2">3215</td><td colspan="2">3290</td></tr>
<tr><td>Self-weight</td><td>ton</td><td colspan="2">13.269</td><td colspan="2">13.641</td><td colspan="2">14.014</td><td colspan="2">14.407</td><td colspan="2">14.780</td><td colspan="2">15.173</td><td colspan="2">15.546</td><td colspan="2">15.918</td><td colspan="2">16.312</td><td colspan="2">16.684</td></tr>
<tr><td>I</td><td>cm^4</td><td colspan="2">1571879</td><td colspan="2">1873925</td><td colspan="2">2208139</td><td colspan="2">2575576</td><td colspan="2">2977274</td><td colspan="2">3414266</td><td colspan="2">3887573</td><td colspan="2">4398208</td><td colspan="2">4947177</td><td colspan="2">5535481</td></tr>
<tr><td>Wi</td><td>cm^3</td><td colspan="2">33699</td><td colspan="2">37720</td><td colspan="2">41911</td><td colspan="2">46269</td><td colspan="2">50789</td><td colspan="2">55470</td><td colspan="2">60308</td><td colspan="2">65300</td><td colspan="2">70446</td><td colspan="2">75743</td></tr>
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<tr><td>M self</td><td>kNm</td><td colspan="2">320.5</td><td colspan="2">329.5</td><td colspan="2">338.5</td><td colspan="2">348.0</td><td colspan="2">357.0</td><td colspan="2">366.5</td><td colspan="2">375.5</td><td colspan="2">384.5</td><td colspan="2">394.0</td><td colspan="2">403.0</td></tr>
<tr><td>Mdesign</td><td>kNm</td><td colspan="2">1227.0</td><td colspan="2">1236.7</td><td colspan="2">1246.4</td><td colspan="2">1256.0</td><td colspan="2">1265.6</td><td colspan="2">1275.2</td><td colspan="2">1284.7</td><td colspan="2">1294.2</td><td colspan="2">1303.7</td><td colspan="2">1313.1</td></tr>
<tr><td>Msdu</td><td>kNm</td><td colspan="2">2450.3</td><td colspan="2">2462.5</td><td colspan="2">2474.6</td><td colspan="2">2486.6</td><td colspan="2">2498.6</td><td colspan="2">2510.5</td><td colspan="2">2522.2</td><td colspan="2">2533.9</td><td colspan="2">2545.5</td><td colspan="2">2557.0</td></tr>
<tr><td>Pi</td><td>kN</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">2312</td><td colspan="2">2190</td><td colspan="2">2060</td><td colspan="2">1950</td><td colspan="2">1845</td><td colspan="2">1750</td><td colspan="2">1675</td></tr>
<tr><td>e</td><td>cm</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">46.29</td><td colspan="2">49.62</td><td colspan="2">52.98</td><td colspan="2">55.89</td><td colspan="2">59.28</td><td colspan="2">62.73</td><td colspan="2">65.58</td></tr>
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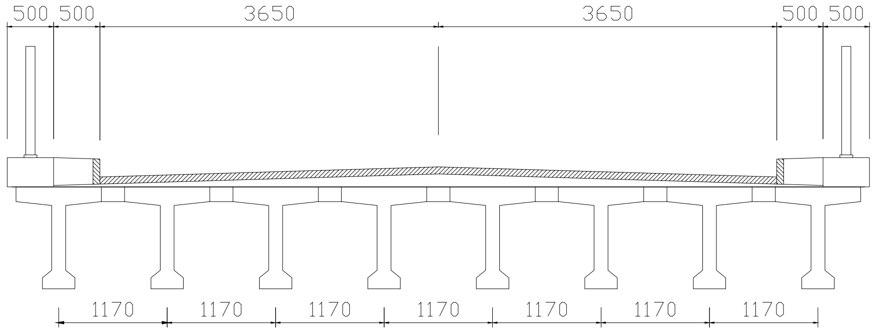
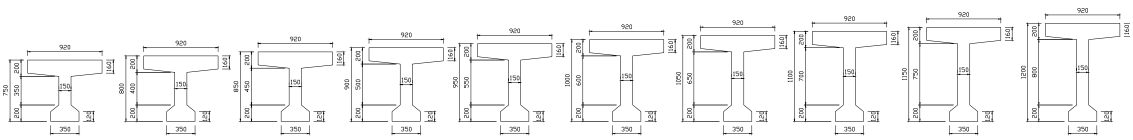
<tr><td>n</td><td>strands</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">16</td><td colspan="2">15</td><td colspan="2">14</td><td colspan="2">14</td><td colspan="2">13</td><td colspan="2">12</td><td colspan="2">12</td></tr>
<tr><td rowspan="2">σpi</td><td>MPa</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">1032</td><td colspan="2">1043</td><td colspan="2">1051</td><td colspan="2">995</td><td colspan="2">1014</td><td colspan="2">1042</td><td colspan="2">997</td></tr>
<tr><td>%</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">62</td><td colspan="2">62</td><td colspan="2">63</td><td colspan="2">60</td><td colspan="2">61</td><td colspan="2">62</td><td colspan="2">60</td></tr>
<tr><td rowspan="2">σ limits</td><td rowspan="2">MPa</td><td>1.76</td><td>2.26</td><td>1.72</td><td>2.21</td><td>1.69</td><td>2.17</td><td>1.66</td><td>2.13</td><td>1.63</td><td>2.09</td><td>1.6</td><td>2.06</td><td>1.58</td><td>2.03</td><td>1.55</td><td>2</td><td>1.53</td><td>1.98</td><td>1.51</td><td>1.95</td></tr>
<tr><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td><td>24</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td></td><td></td><td></td><td></td><td></td><td></td><td>-6.13</td><td>-4.90</td><td>-5.77</td><td>-4.61</td><td>-5.40</td><td>-4.32</td><td>-5.00</td><td>-4.00</td><td>-4.73</td><td>-3.78</td><td>-4.49</td><td>-3.59</td><td>-4.22</td><td>-3.38</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>31.27</td><td>25.02</td><td>28.91</td><td>23.13</td><td>26.56</td><td>21.25</td><td>24.43</td><td>19.55</td><td>22.62</td><td>18.10</td><td>21.03</td><td>16.82</td><td>19.59</td><td>15.67</td></tr>
<tr><td rowspan="2">σ at span</td><td rowspan="2">MPa</td><td></td><td></td><td></td><td></td><td></td><td></td><td>-1.49</td><td>11.84</td><td>-1.40</td><td>10.85</td><td>-1.27</td><td>10.04</td><td>-1.09</td><td>9.39</td><td>-1.00</td><td>8.77</td><td>-0.93</td><td>8.21</td><td>-0.80</td><td>7.75</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>23.75</td><td>-2.13</td><td>21.88</td><td>-1.79</td><td>19.96</td><td>-1.74</td><td>18.21</td><td>-1.76</td><td>16.74</td><td>-1.72</td><td>15.43</td><td>-1.69</td><td>14.27</td><td>-1.66</td></tr>
<tr><td rowspan="2">Debonded</td><td>strands</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">12</td><td colspan="2">11</td><td colspan="2">10</td><td colspan="2">10</td><td colspan="2">9</td><td colspan="2">8</td><td colspan="2">8</td></tr>
<tr><td>X1(m)</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">8.5</td><td colspan="2">8.0</td><td colspan="2">7.5</td><td colspan="2">6.5</td><td colspan="2">6.5</td><td colspan="2">6.0</td><td colspan="2">5.5</td></tr>
<tr><td rowspan="2">σ at support</td><td rowspan="2">MPa</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">-1.53</td><td colspan="2">-1.54</td><td colspan="2">-1.54</td><td colspan="2">-1.43</td><td colspan="2">-1.46</td><td colspan="2">-1.50</td><td colspan="2">-1.41</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">7.82</td><td colspan="2">7.71</td><td colspan="2">7.59</td><td colspan="2">6.98</td><td colspan="2">6.96</td><td colspan="2">7.01</td><td colspan="2">6.53</td></tr>
<tr><td rowspan="2">σ at X1</td><td rowspan="2">MPa</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">-1.59</td><td colspan="2">-1.58</td><td colspan="2">-1.53</td><td colspan="2">-1.57</td><td colspan="2">-1.46</td><td colspan="2">-1.50</td><td colspan="2">-1.50</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">23.92</td><td colspan="2">22.16</td><td colspan="2">20.37</td><td colspan="2">18.97</td><td colspan="2">17.46</td><td colspan="2">16.33</td><td colspan="2">15.35</td></tr>
<tr><td>Mcr</td><td>kNm</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">1256.0</td><td colspan="2">1280.9</td><td colspan="2">1293.2</td><td colspan="2">1301.3</td><td colspan="2">1312.7</td><td colspan="2">1324.1</td><td colspan="2">1335.0</td></tr>
<tr><td>Mu</td><td>kNm</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">2500.3</td><td colspan="2">2525.1</td><td colspan="2">2527.3</td><td colspan="2">2674.1</td><td colspan="2">2643.2</td><td colspan="2">2589.8</td><td colspan="2">2715.6</td></tr>
<tr><td>Cost/girder</td><td>USD</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">649.3</td><td colspan="2">636.0</td><td colspan="2">622.8</td><td colspan="2">629.9</td><td colspan="2">617.1</td><td colspan="2">603.8</td><td colspan="2">611.4</td></tr>
<tr><td>Cost</td><td>USD</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">6685.3</td><td colspan="2">6444.3</td><td colspan="2">6212.3</td><td colspan="2">6195.2</td><td colspan="2">6021.7</td><td colspan="2">5812.1</td><td colspan="2">5849.0</td></tr>
</table>

#	unit	G09 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2615		2690		2765		2840		2915		2990		3065		3140		3215		3290	
Self-weight	ton	13.269		13.641		14.014		14.407		14.780		15.173		15.546		15.918		16.312		16.684	
I	cm^4	1571879		1873925		2208139		2575576		2977274		3414266		3887573		4398208		4947177		5535481	
Wi	cm^3	33699		37720		41911		46269		50789		55470		60308		65300		70446		75743	
Ws	cm^3	55436		61806		68334		75014		81838		88802		95901		103132		110493		117982	
M self	kNm	320.5		329.5		338.5		348.0		357.0		366.5		375.5		384.5		394.0		403.0	
Mdesign	kNm	1227.0		1236.7		1246.4		1256.0		1265.6		1275.2		1284.7		1294.2		1303.7		1313.1	
Msdu	kNm	2450.3		2462.5		2474.6		2486.6		2498.6		2510.5		2522.2		2533.9		2545.5		2557.0	
Pi	kN															1890		1800		1720	
e	cm															59.28		62.15		65.58	
Ap	mm^2															1820		1820		1680	
n	strands															13		13		12	
σpi	MPa															1038		989		1024	
	%															62		59		61	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa															-4.84	-3.88	-4.53	-3.62	-4.33	-3.47
																23.18	18.54	21.48	17.18	20.12	16.10
σ at span	MPa															-1.12	8.67	-0.96	8.18	-0.92	7.66
																17.29	-1.28	15.89	-1.32	14.80	-1.24
Debonded	strands															10		10		9	
	X1(m)															8.0		7.5		7.0	
σ at support	MPa															-1.12		-1.04		-1.08	
																5.35		4.96		5.03	
σ at X1	MPa															-1.27		-1.18		-1.22	
																17.52		16.24		15.28	
Mcr	kNm															1312.2		1318.4		1333.7	
Mu	kNm															2582.9		2719.2		2664.2	
Cost/girder	USD															593.5		600.5		586.6	
Cost	USD															5989.1		6011.6		5783.1	

#	unit	G09 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2615		2690		2765		2840		2915		2990		3065		3140		3215		3290	
Self-weight	ton	13.269		13.641		14.014		14.407		14.780		15.173		15.546		15.918		16.312		16.684	
I	cm^4	1571879		1873925		2208139		2575576		2977274		3414266		3887573		4398208		4947177		5535481	
Wi	cm^3	33699		37720		41911		46269		50789		55470		60308		65300		70446		75743	
Ws	cm^3	55436		61806		68334		75014		81838		88802		95901		103132		110493		117982	
M self	kNm	320.5		329.5		338.5		348.0		357.0		366.5		375.5		384.5		394.0		403.0	
Mdesign	kNm	1227.0		1236.7		1246.4		1256.0		1265.6		1275.2		1284.7		1294.2		1303.7		1313.1	
Msdu	kNm	2450.3		2462.5		2474.6		2486.6		2498.6		2510.5		2522.2		2533.9		2545.5		2557.0	
Pi	kN	3250		2780		2510		2302		2150		2020		1900		1805		1710		1630	
e	cm	31.23		37.68		42.13		46.29		49.62		52.98		56.39		59.28		62.73		65.58	
Ap	mm^2	3360		2800		2520		2240		2100		1960		1820		1820		1680		1680	
n	strands	24		20		18		16		15		14		13		13		12		12	
σpi	MPa	967		993		996		1028		1024		1031		1044		992		1018		970	
	%	58		59		60		62		61		62		63		59		61		58	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-5.88	-4.70	-6.61	-5.29	-6.40	-5.12	-6.10	-4.88	-5.66	-4.53	-5.30	-4.24	-4.97	-3.98	-4.63	-3.70	-4.39	-3.51	-4.11	-3.28
		42.55	34.04	38.11	30.48	34.31	27.45	31.14	24.91	28.38	22.70	26.05	20.84	23.96	19.17	22.13	17.71	20.55	16.44	19.07	15.25
σ at span	MPa	-0.10	17.43	-1.28	14.72	-1.44	13.12	-1.46	11.86	-1.30	10.94	-1.17	10.12	-1.06	9.42	-0.90	8.85	-0.82	8.29	-0.69	7.85
		33.04	-2.37	29.37	-2.30	26.23	-2.29	23.61	-2.24	21.35	-2.21	19.44	-2.15	17.74	-2.13	16.25	-2.11	14.95	-2.07	13.75	-2.08
Debonded	strands	15		14		12		11		10		9		8		8		7		7	
	X1(m)	4.5		6.0		6.5		6.5		6.0		5.5		5.5		5.0		4.5		4.0	
σ at support	MPa	-2.21		-1.98		-2.13		-1.91		-1.89		-1.89		-1.91		-1.78		-1.83		-1.71	
		15.96		11.43		11.44		9.73		9.46		9.30		9.22		8.51		8.56		7.94	
σ at X1	MPa	-1.85		-2.14		-2.05		-2.03		-2.00		-2.00		-1.85		-1.83		-1.90		-1.92	
		35.91		30.77		27.22		24.54		22.48		20.78		19.00		17.72		16.64		15.66	
Mcr	kNm	1238.3		1250.0		1259.5		1270.9		1281.0		1293.5		1303.6		1313.7		1325.5		1333.3	
Mu	kNm	2455.6		2501.0		2564.1		2539.3		2559.4		2557.2		2532.7		2669.0		2611.7		2737.5	
Cost/girder	USD	819.4		746.4		714.2		681.4		669.0		656.6		644.8		653.3		640.9		649.4	
Cost	USD	8212.0		7419.8		7070.9		6717.6		6507.1		6305.7		6149.3		6194.3		6010.8		6060.3	





#	unit	G08 f60																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2831		2906		2981		3056		3131		3206		3281		3356		3431		3506	
Self-weight	ton	14.366		14.738		15.111		15.504		15.877		16.250		16.643		17.015		17.409		17.781	
I	cm^4	1652310		1970466		2322665		2710013		3133598		3594497		4093771		4632472		5211642		5832313	
Wi	cm^3	34338		38439		42717		47169		51790		56577		61527		66638		71908		77335	
Ws	cm^3	61468		68567		75837		83266		90846		98569		106432		114429		122558		130816	
M self	kNm	347.0		356.0		365.0		374.5		383.5		392.5		402.0		411.0		420.5		429.5	
Mdesign	kNm	1272.3		1282.1		1292.0		1301.7		1311.5		1321.2		1331.0		1340.6		1350.3		1359.9	
Msdu	kNm	2596.5		2608.9		2621.2		2633.5		2645.7		2657.8		2669.9		2681.8		2693.7		2705.5	
Pi	kN							2400		2250		2115		1995		1900		1800		1710	
e	cm							47.16		51.13		54.53		57.96		60.95		64.40		67.92	
Ap	mm^2							2380		2240		2100		1960		1960		1820		1680	
n	strands							17		16		15		14		14		13		12	
σpi	MPa							1008		1004		1007		1018		969		989		1018	
	%							60		60		60		61		58		59		61	
σ limits	MPa	1.76	2.26	1.72	2.21	1.69	2.17	1.66	2.13	1.63	2.09	1.6	2.06	1.58	2.03	1.55	2	1.53	1.98	1.51	1.95
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
σ at support	MPa							-5.74	-4.59	-5.48	-4.38	-5.10	-4.08	-4.78	-3.83	-4.46	-3.57	-4.21	-3.37	-4.00	-3.20
								31.85	25.48	29.40	23.52	26.98	21.59	24.87	19.90	23.04	18.43	21.37	17.09	19.90	15.92
σ at span	MPa							-1.24	11.04	-1.26	10.05	-1.12	9.32	-1.01	8.68	-0.87	8.15	-0.78	7.65	-0.72	7.19
								23.91	-2.12	21.99	-1.80	20.04	-1.77	18.34	-1.73	16.87	-1.69	15.52	-1.68	14.34	-1.67
Debonded	strands							13		12		11		10		10		9		8	
	X1(m)							9.0		7.5		7.0		6.5		6.0		5.5		5.5	
σ at support	MPa							-1.35		-1.37		-1.36		-1.37		-1.27		-1.30		-1.33	
								7.49		7.35		7.20		7.11		6.58		6.57		6.63	
σ at X1	MPa							-1.29		-1.52		-1.48		-1.47		-1.44		-1.48		-1.38	
								23.99		22.46		20.67		19.14		17.86		16.70		15.47	
Mcr	kNm							1302.2		1326.5		1337.8		1349.3		1361.7		1371.2		1381.7	
Mu	kNm							2640.4		2694.7		2705.8		2694.5		2841.2		2797.1		2730.6	
Cost/girder	USD							694.0		679.7		666.5		653.2		660.8		647.5		634.7	
Cost	USD							6416.2		6098.0		5891.7		5693.5		5718.3		5532.0		5385.8	

#	unit	G08 f40																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2831		2906		2981		3056		3131		3206		3281		3356		3431		3506	
Self-weight	ton	14.366		14.738		15.111		15.504		15.877		16.250		16.643		17.015		17.409		17.781	
I	cm^4	1652310		1970466		2322665		2710013		3133598		3594497		4093771		4632472		5211642		5832313	
Wi	cm^3	34338		38439		42717		47169		51790		56577		61527		66638		71908		77335	
Ws	cm^3	61468		68567		75837		83266		90846		98569		106432		114429		122558		130816	
M self	kNm	347.0		356.0		365.0		374.5		383.5		392.5		402.0		411.0		420.5		429.5	
Mdesign	kNm	1272.3		1282.1		1292.0		1301.7		1311.5		1321.2		1331.0		1340.6		1350.3		1359.9	
Msdu	kNm	2596.5		2608.9		2621.2		2633.5		2645.7		2657.8		2669.9		2681.8		2693.7		2705.5	
Pi	kN															1930		1850		1770	
e	cm															60.95		64.40		67.34	
Ap	mm^2															1960		1820		1820	
n	strands															14		13		13	
σpi	MPa															985		1016		973	
	%															59		61		58	
σ limits	MPa	1.48	1.76	1.45	1.72	1.42	1.69	1.39	1.66	1.36	1.63	1.34	1.6	1.32	1.58	1.3	1.55	1.28	1.53	1.26	1.51
		18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16	18	16
σ at support	MPa															-4.53	-3.62	-4.33	-3.46	-4.06	-3.25
																23.40	18.72	21.96	17.57	20.46	16.37
σ at span	MPa															-0.94	8.09	-0.90	7.55	-0.78	7.15
																17.24	-1.40	16.11	-1.21	14.91	-1.22
Debonded	strands															10		10		9	
	X1(m)															7.0		7.0		6.5	
σ at support	MPa															-1.29		-1.00		-1.25	
																6.69		5.07		6.30	
σ at X1	MPa															-1.26		-1.21		-1.18	
																17.79		16.64		15.59	
Mcr	kNm															1351.2		1373.5		1382.8	
Mu	kNm															2780.4		2744.6		2880.9	
Cost/girder	USD															634.9		621.6		628.6	
Cost	USD															5583.5		5476.4		5444.4	

#	unit	G08 f80																			
h	cm	75		80		85		90		95		100		105		110		115		120	
A	cm^2	2831		2906		2981		3056		3131		3206		3281		3356		3431		3506	
Self-weight	ton	14.366		14.738		15.111		15.504		15.877		16.250		16.643		17.015		17.409		17.781	
I	cm^4	1652310		1970466		2322665		2710013		3133598		3594497		4093771		4632472		5211642		5832313	
Wi	cm^3	34338		38439		42717		47169		51790		56577		61527		66638		71908		77335	
Ws	cm^3	61468		68567		75837		83266		90846		98569		106432		114429		122558		130816	
M self	kNm	347.0		356.0		365.0		374.5		383.5		392.5		402.0		411.0		420.5		429.5	
Mdesign	kNm	1272.3		1282.1		1292.0		1301.7		1311.5		1321.2		1331.0		1340.6		1350.3		1359.9	
Msdu	kNm	2596.5		2608.9		2621.2		2633.5		2645.7		2657.8		2669.9		2681.8		2693.7		2705.5	
Pi	kN	3620		2900		2570		2400		2210		2075		1955		1845		1755		1665	
e	cm	30.81		38.41		43.82		47.16		51.13		54.53		57.96		61.44		64.40		67.92	
Ap	mm^2	3640		2940		2520		2380		2240		2100		1960		1820		1820		1680	
n	strands	26		21		18		17		16		15		14		13		13		12	
σpi	MPa	995		986		1020		1008		987		988		997		1014		964		991	
	%	60		59		61		60		59		59		60		61		58		59	
σ limits	MPa	2.26	2.71	2.21	2.65	2.17	2.6	2.13	2.56	2.09	2.52	2.06	2.48	2.03	2.44	2	2.41	1.98	2.38	1.95	2.35
		36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32	36	32
σ at support	MPa	-5.36	-4.29	-6.27	-5.01	-6.23	-4.98	-5.74	-4.59	-5.38	-4.30	-5.01	-4.01	-4.69	-3.75	-4.41	-3.53	-4.11	-3.29	-3.90	-3.12
		45.27	36.21	38.96	31.17	34.98	27.99	31.85	25.48	28.88	23.10	26.47	21.18	24.38	19.50	22.51	18.01	20.83	16.67	19.37	15.50
σ at span	MPa	0.29	16.41	-1.07	13.69	-1.42	12.05	-1.24	11.04	-1.16	10.13	-1.02	9.40	-0.91	8.75	-0.82	8.19	-0.68	7.73	-0.61	7.28
		35.16	-0.84	29.70	-2.19	26.44	-2.26	23.91	-2.12	21.47	-2.22	19.53	-2.18	17.84	-2.13	16.34	-2.11	14.98	-2.11	13.82	-2.09
Debonded	strands	16		14		12		11		10		9		8		8		7		6	
	X1(m)	7.5		5.5		6.5		6.0		5.5		5.0		5.0		4.5		4.0		4.0	
σ at support	MPa	-2.06		-2.09		-2.08		-2.03		-2.02		-2.00		-2.01		-1.70		-1.90		-1.95	
		17.41		12.99		11.66		11.24		10.83		10.59		10.45		8.66		9.62		9.69	
σ at X1	MPa	-0.07		-2.13		-2.01		-1.96		-2.01		-2.02		-1.86		-1.90		-1.91		-1.79	
		35.79		31.57		27.49		25.18		22.97		21.27		19.47		18.21		17.09		15.82	
Mcr	kNm	1336.5		1300.0		1306.8		1322.6		1326.8		1338.4		1350.1		1360.5		1369.5		1380.2	
Mu	kNm	2596.0		2635.6		2621.7		2678.7		2728.7		2735.6		2720.4		2683.2		2819.5		2749.7	
Cost/girder	USD	890.1		792.7		740.1		727.7		715.3		702.9		691.1		678.7		687.2		675.3	
Cost	USD	8621.0		6990.8		6570.6		6367.6		6173.5		5988.5		5848.4		5717.4		5717.4		5586.3	

#	unit	G14 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2003	2078	2153	2228	2303	2378	2453	2528	2603	2678
Self-weight	ton	10.164	10.536	10.909	11.302	11.675	12.068	12.441	12.813	13.207	13.579
Total weight	ton	142.292	147.508	152.725	158.231	163.447	168.953	174.170	179.386	184.892	190.109
Ap	mm^2	2100	1820	1680	1540	1400	1400	1260	1260	1120	1120
n	strands	15	13	12	11	10	10	9	9	8	8
Debonded	strands	12	10	9	9	8	7	7	7	6	6
	X1(m)	7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0	4.5	4.5
	length(m)	126.0	97.5	87.8	81.0	66.0	57.8	52.5	52.5	40.5	40.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	63.000	48.750	43.875	40.500	33.000	28.875	26.250	26.250	20.250	20.250
Vc	m3	4.146	4.301	4.457	4.612	4.767	4.922	5.078	5.233	5.388	5.543
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost	223.895	232.279	240.662	249.046	257.429	265.813	274.196	282.580	290.963	299.347
Wp	kg	341.240	295.741	272.992	250.242	227.493	227.493	204.744	204.744	181.994	181.994
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	324.178	280.954	259.342	237.730	216.118	216.118	194.507	194.507	172.895	172.895
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	330.089	338.104	346.119	354.134	362.149	370.164	378.179	386.194	394.209	402.224
	total	513.867	521.882	529.897	537.912	545.927	590.697	598.712	606.727	614.742	622.757
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	231.240	234.847	238.454	242.060	245.667	265.814	269.421	273.027	276.634	280.241
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094
Materials cost	Girder	611.073	561.983	543.879	527.276	506.548	510.806	494.953	503.336	484.108	492.492
	Total	936.407	890.923	876.427	863.430	846.308	870.714	858.467	870.457	854.836	866.826
Transversal		66.9	63.6	62.6	61.7	60.5	62.2	61.3	62.2	61.1	61.9
Loss		100.3	95.5	93.9	92.5	90.7	93.3	92.0	93.3	91.6	92.9
Anchorage	general	630.0	570.0	540.0	510.0	480.0	480.0	450.0	450.0	420.0	420.0
	particular	126.0	114.0	108.0	102.0	96.0	96.0	90.0	90.0	84.0	84.0
Formwork		82.9	86.0	89.1	92.2	95.3	98.4	101.6	104.7	107.8	110.9
Labor	concrete	179.1	185.8	192.5	199.2	205.9	212.7	219.4	226.1	232.8	239.5
	steel	706.2	674.5	660.1	645.7	631.3	647.4	633.0	635.9	621.5	624.4
Transportation	USD/girder	40.7	42.1	43.6	45.2	46.7	48.3	49.8	51.3	52.8	54.3
Administration		1258.5	1208.9	1193.3	1178.6	1161.2	1192.4	1178.2	1193.5	1177.1	1192.5
Cost/girder	USD	3497.0	3361.4	3319.6	3280.5	3233.9	3321.4	3283.6	3327.3	3283.5	3327.1
Cost	USD	48958.1	47060.2	46474.1	45927.5	45274.5	46499.7	45971.0	46582.0	45968.4	46579.4
Girder setting	USD	704.58	715.02	725.45	736.46	746.89	757.91	768.34	778.77	789.7848	800.22
Concrete joint	USD	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34
Cost	USD	50696.0	48808.6	48232.9	47697.3	47054.7	48290.9	47772.6	48394.1	47791.5	48413.0

#	unit	G13 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2111	2186	2261	2336	2411	2486	2561	2636	2711	2786
Self-weight	ton	10.702	11.095	11.468	11.840	12.234	12.606	12.979	13.372	13.745	14.138
Total weight	ton	139.125	144.238	149.081	153.925	159.038	163.882	168.726	173.839	178.682	183.795
Ap	mm^2		1960	1820	1680	1540	1400	1400	1400	1260	1260
n	strands		14	13	12	11	10	10	10	9	9
Debonded	strands		11	10	9	8	7	7	7	6	6
	X1(m)		7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0	4.5
	length(m)		115.5	97.5	87.8	72.0	57.8	57.8	52.5	45.0	40.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	0.000	57.750	48.750	43.875	36.000	28.875	28.875	26.250	22.500	20.250
Vc	m^3	4.370	4.525	4.680	4.836	4.991	5.146	5.301	5.457	5.612	5.767
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost	235.968	244.351	252.735	261.118	269.502	277.885	286.269	294.652	303.036	311.419
Wp	kg		318.490	295.741	272.992	250.242	227.493	227.493	227.493	204.744	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	0.000	302.566	280.954	259.342	237.730	216.118	216.118	216.118	194.507	194.507
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	341.686	349.701	357.716	365.731	373.746	381.761	389.776	397.791	405.806	413.821
	total	525.463	533.478	541.493	549.508	557.523	602.294	610.309	618.324	626.339	634.354
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	236.459	240.065	243.672	247.279	250.885	271.032	274.639	278.246	281.852	285.459
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	235.968	604.667	582.438	564.335	543.232	522.878	531.262	537.020	520.042	526.176
	Total	573.758	946.064	927.442	912.945	895.449	895.242	907.232	916.598	903.226	912.966
Transversal		44.1	72.8	71.3	70.2	68.9	68.9	69.8	70.5	69.5	70.2
Loss		61.8	101.9	99.9	98.3	96.4	96.4	97.7	98.7	97.3	98.3
Anchorage	general	180.0	600.0	570.0	540.0	510.0	480.0	480.0	480.0	450.0	450.0
	particular	36.0	120.0	114.0	108.0	102.0	96.0	96.0	96.0	90.0	90.0
Formwork		87.4	90.5	93.6	96.7	99.8	102.9	106.0	109.1	112.2	115.3
Labor	concrete	188.8	195.5	202.2	208.9	215.6	222.3	229.0	235.7	242.4	249.1
	steel	451.0	696.0	681.5	667.1	652.7	651.6	654.5	657.3	642.9	645.8
Transportation	USD/girder	42.8	44.4	45.9	47.4	48.9	50.4	51.9	53.5	55.0	56.6
Administration			1272.5	1254.1	1238.4	1220.7	1222.1	1237.5	1251.2	1236.2	1250.1
Cost/girder	USD	1485.7	3539.5	3489.9	3448.0	3400.5	3405.9	3449.6	3488.7	3448.7	3488.5
Cost	USD		46013.5	45369.3	44823.4	44207.1	44276.5	44845.3	45352.8	44833.6	45349.9
Girder setting	USD	668.25	678.48	688.16	697.85	708.08	717.76	727.45	737.67	747.36	757.59
Concrete joint	USD	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86
Cost	USD	1622.1	47645.8	47011.4	46475.1	45869.0	45948.1	46526.6	47044.3	46534.8	47061.4

#	unit	G13 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2111	2186	2261	2336	2411	2486	2561	2636	2711	2786
Self-weight	ton	10.702	11.095	11.468	11.840	12.234	12.606	12.979	13.372	13.745	14.138
Total weight	ton	139.125	144.238	149.081	153.925	159.038	163.882	168.726	173.839	178.682	183.795
Ap	mm^2		1960	1820	1680	1540	1400	1400	1400	1260	1260
n	strands		14	13	12	11	10	10	10	9	9
Debonded	strands		11	10	9	8	7	7	7	6	6
	X1(m)		7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0	4.5
	length(m)		115.5	97.5	87.8	72.0	57.8	57.8	52.5	45.0	40.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	0.000	57.750	48.750	43.875	36.000	28.875	28.875	26.250	22.500	20.250
Vc	m^3	4.370	4.525	4.680	4.836	4.991	5.146	5.301	5.457	5.612	5.767
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost	235.968	244.351	252.735	261.118	269.502	277.885	286.269	294.652	303.036	311.419
Wp	kg		318.490	295.741	272.992	250.242	227.493	227.493	227.493	204.744	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	0.000	302.566	280.954	259.342	237.730	216.118	216.118	216.118	194.507	194.507
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	341.686	349.701	357.716	365.731	373.746	381.761	389.776	397.791	405.806	413.821
	total	525.463	533.478	541.493	549.508	557.523	602.294	610.309	618.324	626.339	634.354
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	236.459	240.065	243.672	247.279	250.885	271.032	274.639	278.246	281.852	285.459
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	235.968	604.667	582.438	564.335	543.232	522.878	531.262	537.020	520.042	526.176
	Total	573.758	946.064	927.442	912.945	895.449	895.242	907.232	916.598	903.226	912.966
Transversal		44.1	72.8	71.3	70.2	68.9	68.9	69.8	70.5	69.5	70.2
Loss		61.8	101.9	99.9	98.3	96.4	96.4	97.7	98.7	97.3	98.3
Anchorage	general	180.0	600.0	570.0	540.0	510.0	480.0	480.0	480.0	450.0	450.0
	particular	36.0	120.0	114.0	108.0	102.0	96.0	96.0	96.0	90.0	90.0
Formwork		87.4	90.5	93.6	96.7	99.8	102.9	106.0	109.1	112.2	115.3
Labor	concrete	188.8	195.5	202.2	208.9	215.6	222.3	229.0	235.7	242.4	249.1
	steel	451.0	696.0	681.5	667.1	652.7	651.6	654.5	657.3	642.9	645.8
Transportation	USD/girder	42.8	44.4	45.9	47.4	48.9	50.4	51.9	53.5	55.0	56.6
Administration			1272.5	1254.1	1238.4	1220.7	1222.1	1237.5	1251.2	1236.2	1250.1
Cost/girder	USD	1485.7	3539.5	3489.9	3448.0	3400.5	3405.9	3449.6	3488.7	3448.7	3488.5
Cost	USD		46013.5	45369.3	44823.4	44207.1	44276.5	44845.3	45352.8	44833.6	45349.9
Girder setting	USD	668.25	678.48	688.16	697.85	708.08	717.76	727.45	737.67	747.36	757.59
Concrete joint	USD	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86
Cost	USD	1622.1	47645.8	47011.4	46475.1	45869.0	45948.1	46526.6	47044.3	46534.8	47061.4

#	unit	G12 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2219	2294	2369	2444	2519	2594	2669	2744	2819	2894
Self-weight	ton	11.261	11.633	12.006	12.399	12.772	13.165	13.538	13.910	14.304	14.676
Total weight	ton	135.130	139.601	144.072	148.792	153.263	157.982	162.454	166.925	171.644	176.116
Ap	mm^2		2240	1960	1820	1680	1540	1540	1400	1400	1260
n	strands		16	14	13	12	11	11	10	10	9
Debonded	strands		12	11	10	9	8	8	7	7	6
	X1(m)		7.5	7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0
	length(m)		135.0	115.5	97.5	87.8	72.0	66.0	57.8	52.5	45.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost		67.500	57.750	48.750	43.875	36.000	33.000	28.875	26.250	22.500
Vc	m^3		4.749	4.904	5.059	5.214	5.370	5.525	5.680	5.835	5.991
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost		256.423	264.807	273.190	281.574	289.957	298.341	306.724	315.108	323.491
Wp	kg		363.989	318.490	295.741	272.992	250.242	250.242	227.493	227.493	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost		345.789	302.566	280.954	259.342	237.730	237.730	216.118	216.118	194.507
RC bars	kg		183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg		361.203	369.218	377.233	385.248	393.263	401.278	409.293	417.308	425.323
	total		544.980	552.995	561.010	569.025	613.796	621.811	629.826	637.841	645.856
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost		245.241	248.848	252.455	256.061	276.208	279.815	283.422	287.028	290.635
PC slab	strands		33	33	33	33	33	33	33	33	33
	wp (kg)		344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost		327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage		66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost		990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder		101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder		669.713	625.123	602.894	584.791	563.688	569.071	551.718	557.476	540.498
	Total		1016.285	975.302	956.680	942.184	941.227	950.217	936.471	945.836	932.464
Transversal			84.7	81.3	79.7	78.5	78.4	79.2	78.0	78.8	77.7
Loss			110.1	105.7	103.6	102.1	102.0	102.9	101.5	102.5	101.0
Anchorage	general		660.0	600.0	570.0	540.0	510.0	510.0	480.0	480.0	450.0
	particular		132.0	120.0	114.0	108.0	102.0	102.0	96.0	96.0	90.0
Formwork			95.0	98.1	101.2	104.3	107.4	110.5	113.6	116.7	119.8
Labor	concrete		205.1	211.8	218.6	225.3	232.0	238.7	245.4	252.1	258.8
	steel		734.7	703.0	688.6	674.2	673.0	675.9	661.5	664.4	650.0
Transportation	USD/girder		46.5	48.0	49.6	51.1	52.7	54.2	55.6	57.2	58.7
Administration			1360.7	1313.7	1295.2	1279.4	1280.4	1293.9	1278.6	1292.3	1277.2
Cost/girder	USD		3785.0	3656.8	3607.2	3565.0	3569.1	3607.4	3566.6	3605.8	3565.7
Cost	USD		45420.5	43882.2	43286.1	42780.3	42828.7	43289.0	42799.7	43269.4	42788.4
Girder setting	USD		639.20	648.14	657.58	666.53	675.96	684.91	693.85	703.29	712.23
Concrete joint	USD		874.37	874.37	874.37	874.37	874.37	874.37	874.37	874.37	874.37
Cost	USD		46934.1	45404.7	44818.1	44321.2	44379.0	44848.3	44368.0	44847.0	44375.0

#	unit	G11 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2345	2420	2495	2570	2645	2720	2795	2870	2945	3020
Self-weight	ton	11.903	12.275	12.648	13.041	13.414	13.786	14.180	14.552	14.945	15.318
Total weight	ton	130.928	135.026	139.125	143.451	147.550	151.648	155.975	160.073	164.399	168.498
Ap	mm^2			2100	1960	1820	1680	1540	1540	1400	1400
n	strands			15	14	13	12	11	11	10	10
Debonded	strands			12	11	10	9	8	8	7	7
	X1(m)			7.5	7.0	6.5	6.5	6.0	5.5	5.0	5.0
	length(m)			135.0	115.5	97.5	87.8	72.0	66.0	52.5	52.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost			67.500	57.750	48.750	43.875	36.000	33.000	26.250	26.250
Vc	m^3			5.165	5.320	5.475	5.630	5.786	5.941	6.096	6.251
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost			278.891	287.275	295.658	304.042	312.425	320.809	329.192	337.576
Wp	kg			341.240	318.490	295.741	272.992	250.242	250.242	227.493	227.493
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost			324.178	302.566	280.954	259.342	237.730	237.730	216.118	216.118
RC bars	kg			183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg			392.514	400.529	408.544	416.559	424.574	432.589	440.604	448.619
	total			576.291	584.306	592.321	637.092	645.107	653.122	661.137	669.152
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost			259.331	262.938	266.545	286.691	290.298	293.905	297.512	301.118
PC slab	strands			33	33	33	33	33	33	33	33
	wp (kg)			344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost			327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage			66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost			990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder			101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder			670.569	647.590	625.362	607.259	586.155	591.539	571.560	579.944
	Total			1031.231	1011.860	993.238	995.281	977.785	986.775	970.403	982.394
Transversal				93.7	92.0	90.3	90.5	88.9	89.7	88.2	89.3
Loss				112.5	110.4	108.4	108.6	106.7	107.6	105.9	107.2
Anchorage	general			630.0	600.0	570.0	540.0	510.0	510.0	480.0	480.0
	particular			126.0	120.0	114.0	108.0	102.0	102.0	96.0	96.0
Formwork				103.3	106.4	109.5	112.6	115.7	118.8	121.9	125.0
Labor	concrete			223.1	229.8	236.5	243.2	249.9	256.6	263.4	270.1
	steel			728.7	714.3	699.8	698.7	684.3	687.2	672.8	675.6
Transportation	USD/girder			50.6	52.2	53.7	55.1	56.7	58.2	59.8	61.3
Administration				1383.6	1364.6	1346.0	1349.0	1331.2	1344.7	1327.6	1343.1
Cost/girder	USD			3852.8	3801.5	3751.5	3761.0	3713.1	3751.6	3705.9	3749.9
Cost	USD			42380.3	41816.0	41266.1	41370.6	40844.6	41267.8	40764.7	41249.2
Girder setting	USD			608.25	616.90	625.10	633.30	641.95	650.15	658.80	667.00
Concrete joint	USD			794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88
Cost	USD			43783.4	43227.8	42686.1	42798.8	42281.4	42712.9	42218.4	42711.1

#	unit	G10 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2489	2564	2639	2714	2789	2864	2939	3014	3089	3164
Self-weight	ton	12.627	13.000	13.393	13.766	14.138	14.531	14.904	15.277	15.670	16.043
Total weight	ton	126.270	129.996	133.929	137.655	141.381	145.314	149.040	152.766	156.699	160.425
Ap	mm^2			2240	2100	1960	1820	1680	1680	1540	1540
n	strands			16	15	14	13	12	12	11	11
Debonded	strands			12	11	10	10	9	8	8	7
	X1(m)			9.5	7.5	7.0	6.5	6.5	6.0	5.5	5.0
	length(m)			171.0	123.8	105.0	97.5	87.8	72.0	66.0	52.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost			85.500	61.875	52.500	48.750	43.875	36.000	33.000	26.250
Vc	m^3			5.463	5.618	5.773	5.928	6.084	6.239	6.394	6.549
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost			294.987	303.371	311.754	320.138	328.521	336.905	345.288	353.672
Wp	kg			363.989	341.240	318.490	295.741	272.992	272.992	250.242	250.242
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost			345.789	324.178	302.566	280.954	259.342	259.342	237.730	237.730
RC bars	kg			183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg			404.863	412.878	420.893	428.908	436.923	444.938	452.953	460.968
	total			588.641	596.656	604.671	649.441	657.456	665.471	673.486	681.501
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost			264.888	268.495	272.102	292.249	295.855	299.462	303.069	306.676
PC slab	strands			33	33	33	33	33	33	33	33
	wp (kg)			344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost			327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage			66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost			990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder			101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder			726.277	689.423	666.820	649.842	631.738	632.247	616.019	617.652
	Total			1092.497	1059.250	1040.254	1043.422	1028.925	1033.041	1020.419	1025.659
Transversal				109.2	105.9	104.0	104.3	102.9	103.3	102.0	102.6
Loss				120.2	116.5	114.4	114.8	113.2	113.6	112.2	112.8
Anchorage	general			660.0	630.0	600.0	570.0	540.0	540.0	510.0	510.0
	particular			132.0	126.0	120.0	114.0	108.0	108.0	102.0	102.0
Formwork				109.3	112.4	115.5	118.6	121.7	124.8	127.9	131.0
Labor	concrete			236.0	242.7	249.4	256.1	262.8	269.5	276.2	282.9
	steel			750.4	736.0	721.6	720.4	706.0	708.9	694.5	697.4
Transportation	USD/girder			53.6	55.1	56.6	58.1	59.6	61.1	62.7	64.2
Administration				1457.6	1429.3	1410.4	1414.1	1398.2	1408.5	1393.8	1404.9
Cost/girder	USD			4060.8	3983.1	3932.1	3943.9	3901.3	3930.8	3891.8	3923.4
Cost	USD			40607.6	39831.3	39321.5	39438.7	39013.0	39308.0	38918.3	39234.3
Girder setting	USD			567.86	575.31	582.76	590.63	598.08	605.53	613.40	620.85
Concrete joint	USD			715.39	715.39	715.39	715.39	715.39	715.39	715.39	715.39
Cost	USD			41890.8	41122.0	40619.6	40744.7	40326.5	40629.0	40247.1	40570.6

#	unit	G09 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2615	2690	2765	2840	2915	2990	3065	3140	3215	3290
Self-weight	ton	13.269	13.641	14.014	14.407	14.780	15.173	15.546	15.918	16.312	16.684
Total weight	ton	119.418	122.772	126.125	129.665	133.018	136.558	139.911	143.265	146.804	150.158
Ap	mm^2				2240	2100	1960	1960	1820	1680	1680
n	strands				16	15	14	14	13	12	12
Debonded	strands				12	11	10	10	9	8	8
	X1(m)				8.5	8.0	7.5	6.5	6.5	6.0	5.5
	length(m)				153.0	132.0	112.5	97.5	87.8	72.0	66.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost				76.500	66.000	56.250	48.750	43.875	36.000	33.000
Vc	m^3				5.879	6.034	6.189	6.345	6.500	6.655	6.810
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost				317.455	325.839	334.222	342.606	350.989	359.373	367.756
Wp	kg				363.989	341.240	318.490	318.490	295.741	272.992	272.992
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				345.789	324.178	302.566	302.566	280.954	259.342	259.342
RC bars	kg				183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg				475.956	483.971	491.986	500.001	508.016	516.031	524.046
	total				659.733	667.748	712.519	720.534	728.549	736.564	744.579
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost				296.880	300.487	320.633	324.240	327.847	331.454	335.060
PC slab	strands				33	33	33	33	33	33	33
	wp (kg)				344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage				66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost				990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder				101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder				739.745	716.016	693.038	693.921	675.818	654.715	660.098
	Total				1137.956	1117.834	1115.003	1119.493	1104.996	1087.500	1096.490
Transversal					126.4	124.2	123.9	124.4	122.8	120.8	121.8
Loss					126.4	124.2	123.9	124.4	122.8	120.8	121.8
Anchorage	general				660.0	630.0	600.0	600.0	570.0	540.0	540.0
	particular				132.0	126.0	120.0	120.0	114.0	108.0	108.0
Formwork					117.6	120.7	123.8	126.9	130.0	133.1	136.2
Labor	concrete				254.0	260.7	267.4	274.1	280.8	287.5	294.2
	steel				776.0	761.6	760.4	763.3	748.9	734.5	737.4
Transportation	USD/girder				57.6	59.1	60.7	62.2	63.7	65.2	66.7
Administration					1526.4	1506.6	1506.3	1516.9	1500.9	1482.8	1496.5
Cost/girder	USD				4254.3	4200.9	4201.3	4231.6	4188.8	4140.3	4179.1
Cost	USD				38289.0	37807.9	37811.9	38084.5	37698.9	37263.1	37612.2
Girder setting	USD				529.33	536.04	543.12	549.82	556.53	563.61	570.32
Concrete joint	USD				794.88	794.88	794.88	794.88	794.88	794.88	794.88
Cost	USD				39613.3	39138.8	39149.9	39429.2	39050.3	38621.6	38977.4

#	unit	G08 f60									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2831	2906	2981	3056	3131	3206	3281	3356	3431	3506
Self-weight	ton	14.366	14.738	15.111	15.504	15.877	16.250	16.643	17.015	17.409	17.781
Total weight	ton	114.926	117.907	120.888	124.034	127.015	129.996	133.142	136.123	139.270	142.250
Ap	mm^2				2380	2240	2100	1960	1960	1820	1680
n	strands				17	16	15	14	14	13	12
Debonded	strands				13	12	11	10	10	9	8
	X1(m)				9.0	7.5	7.0	6.5	6.0	5.5	5.5
	length(m)				175.5	135.0	115.5	97.5	90.0	74.3	66.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost				87.750	67.500	57.750	48.750	45.000	37.125	33.000
Vc	m^3				6.326	6.481	6.636	6.792	6.947	7.102	7.257
	Unit cost	54	54	54	54	54	54	54	54	54	54
	cost				341.600	349.983	358.367	366.750	375.134	383.517	391.901
Wp	kg				386.738	363.989	341.240	318.490	318.490	295.741	272.992
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				367.401	345.789	324.178	302.566	302.566	280.954	259.342
RC bars	kg				183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg				504.958	512.973	520.988	529.003	537.018	545.033	553.048
	total				688.735	696.750	741.521	749.536	757.551	765.566	773.581
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost				309.931	313.538	333.684	337.291	340.898	344.505	348.111
PC slab	strands				33	33	33	33	33	33	33
	wp (kg)				344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage				66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost				990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder				101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder				796.751	763.273	740.294	718.066	722.699	701.596	684.243
	Total				1208.013	1178.142	1175.310	1156.688	1164.929	1147.432	1133.685
Transversal					151.0	147.3	146.9	144.6	145.6	143.4	141.7
Loss					135.9	132.5	132.2	130.1	131.1	129.1	127.5
Anchorage	general				690.0	660.0	630.0	600.0	600.0	570.0	540.0
	particular				138.0	132.0	126.0	120.0	120.0	114.0	108.0
Formwork					126.5	129.6	132.7	135.8	138.9	142.0	145.1
Labor	concrete				273.3	280.0	286.7	293.4	300.1	306.8	313.5
	steel				803.7	789.3	788.1	773.7	776.6	762.2	747.8
Transportation	USD/girder				62.0	63.5	65.0	66.6	68.1	69.6	71.1
Administration					1620.3	1593.8	1593.5	1574.5	1587.7	1569.6	1553.9
Cost/girder	USD				4518.8	4446.2	4446.5	4395.5	4433.0	4384.2	4342.5
Cost	USD				36150.1	35569.4	35571.8	35163.9	35464.4	35073.7	34739.7
Girder setting	USD				488.07	494.03	499.99	506.28	512.25	518.54	524.50
Concrete joint	USD				695.52	695.52	695.52	695.52	695.52	695.52	695.52
Cost	USD				37333.7	36758.9	36767.3	36365.7	36672.2	36287.8	35959.7

#	unit	G14 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2003	2078	2153	2228	2303	2378	2453	2528	2603	2678
Self-weight	ton	10.164	10.536	10.909	11.302	11.675	12.068	12.441	12.813	13.207	13.579
Total weight	ton	142.292	147.508	152.725	158.231	163.447	168.953	174.170	179.386	184.892	190.109
Ap	mm^2				1680	1540	1400	1260	1260	1260	1120
n	strands				12	11	10	9	9	9	8
Debonded	strands				10	9	8	7	7	7	6
	X1(m)				7.0	6.5	6.0	6.0	5.5	5.5	5.0
	length(m)				105.0	87.8	72.0	63.0	57.8	57.8	45.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost				52.500	43.875	36.000	31.500	28.875	28.875	22.500
Vc	m^3				4.612	4.767	4.922	5.078	5.233	5.388	5.543
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost				230.598	238.361	246.123	253.886	261.648	269.411	277.173
Wp	kg				272.992	250.242	227.493	204.744	204.744	204.744	181.994
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				259.342	237.730	216.118	194.507	194.507	194.507	172.895
RC bars	kg				183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg				354.134	362.149	370.164	378.179	386.194	394.209	402.224
	total				537.912	545.927	590.697	598.712	606.727	614.742	622.757
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost				242.060	245.667	265.814	269.421	273.027	276.634	280.241
PC slab	strands				33	33	33	33	33	33	33
	wp (kg)				344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost				327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage				66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost				990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder				94.094	94.094	94.094	94.094	94.094	94.094	94.094
Materials cost	Girder				542.440	519.966	498.241	479.892	485.030	492.792	472.568
	Total				878.594	859.726	858.149	843.406	852.150	863.520	846.902
Transversal					62.8	61.4	61.3	60.2	60.9	61.7	60.5
Loss					94.1	92.1	91.9	90.4	91.3	92.5	90.7
Anchorage	general				540.0	510.0	480.0	450.0	450.0	450.0	420.0
	particular				108.0	102.0	96.0	90.0	90.0	90.0	84.0
Formwork					92.2	95.3	98.4	101.6	104.7	107.8	110.9
Labor	concrete				184.5	190.7	196.9	203.1	209.3	215.5	221.7
	steel				663.0	648.6	647.4	633.0	635.9	638.8	624.4
Transportation	USD/girder				45.2	46.7	48.3	49.8	51.3	52.8	54.3
Administration					1193.4	1174.6	1174.9	1158.8	1171.7	1186.4	1169.0
Cost/girder	USD				3321.8	3271.2	3273.3	3230.2	3267.1	3309.0	3262.4
Cost	USD				46505.3	45796.6	45826.4	45222.9	45740.1	46325.3	45674.0
Girder setting	USD				736.46	746.89	757.91	768.34	778.77	789.78	800.22
Concrete joint	USD				1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34
Cost	USD				48275.1	47576.8	47617.7	47024.6	47552.2	48148.4	47507.6

#	unit	G13 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2111	2186	2261	2336	2411	2486	2561	2636	2711	2786
Self-weight	ton	10.702	11.095	11.468	11.840	12.234	12.606	12.979	13.372	13.745	14.138
Total weight	ton	139.125	144.238	149.081	153.925	159.038	163.882	168.726	173.839	178.682	183.795
Ap	mm^2					1680	1540	1400	1400	1260	1260
n	strands					12	11	10	10	9	9
Debonded	strands					10	9	8	8	7	7
	X1(m)					7.0	6.5	6.5	6.0	6.0	5.5
	length(m)					105.0	87.8	78.0	72.0	63.0	57.8
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost					52.500	43.875	39.000	36.000	31.500	28.875
Vc	m^3					4.991	5.146	5.301	5.457	5.612	5.767
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost					249.539	257.301	265.064	272.826	280.589	288.351
Wp	kg					272.992	250.242	227.493	227.493	204.744	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost					259.342	237.730	216.118	216.118	194.507	194.507
RC bars	kg					183.778	220.533	220.533	220.533	220.533	220.533
	kg					373.746	381.761	389.776	397.791	405.806	413.821
	total					557.523	602.294	610.309	618.324	626.339	634.354
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost					250.885	271.032	274.639	278.246	281.852	285.459
PC slab	strands					33	33	33	33	33	33
	wp (kg)					344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost					327.310	327.310	327.310	327.310	327.310	327.310
	anchorage					66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost					990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder					101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder					561.381	538.906	520.182	524.944	506.595	511.733
	Total					913.598	911.270	896.152	904.522	889.779	898.523
Transversal						70.3	70.1	68.9	69.6	68.4	69.1
Loss						98.4	98.1	96.5	97.4	95.8	96.8
Anchorage	general					540.0	510.0	480.0	480.0	450.0	450.0
	particular					108.0	102.0	96.0	96.0	90.0	90.0
Formwork						99.8	102.9	106.0	109.1	112.2	115.3
Labor	concrete					199.6	205.8	212.1	218.3	224.5	230.7
	steel					670.0	668.9	654.5	657.3	642.9	645.8
Transportation	USD/girder					48.9	50.4	51.9	53.5	55.0	56.6
Administration						1236.8	1236.6	1220.2	1232.9	1216.7	1229.7
Cost/girder	USD					3445.5	3446.1	3402.2	3438.6	3395.4	3432.5
Cost	USD					44791.3	44799.8	44228.7	44702.2	44140.0	44622.3
Girder setting	USD					708.08	717.76	727.45	737.68	747.36	757.59
Concrete joint	USD					953.86	953.86	953.86	953.86	953.86	953.86
Cost	USD					46453.2	46471.4	45910.1	46393.7	45841.2	46333.8

#	unit	G12 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2219	2294	2369	2444	2519	2594	2669	2744	2819	2894
Self-weight	ton	11.261	11.633	12.006	12.399	12.772	13.165	13.538	13.910	14.304	14.676
Total weight	ton	135.130	139.601	144.072	148.792	153.263	157.982	162.454	166.925	171.644	176.116
Ap	mm^2					1820	1680	1540	1400	1400	1400
n	strands					13	12	11	10	10	10
Debonded	strands					10	10	9	8	8	8
	X1(m)					8.0	7.0	6.5	6.5	6.0	5.5
	length(m)					120.0	105.0	87.8	78.0	72.0	66.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost					60.000	52.500	43.875	39.000	36.000	33.000
Vc	m^3					5.214	5.370	5.525	5.680	5.835	5.991
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost					260.717	268.479	276.242	284.004	291.767	299.529
Wp	kg					295.741	272.992	250.242	227.493	227.493	227.493
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost					280.954	259.342	237.730	216.118	216.118	216.118
RC bars	kg					183.778	220.533	220.533	220.533	220.533	220.533
	kg					385.248	393.263	401.278	409.293	417.308	425.323
	total					569.025	613.796	621.811	629.826	637.841	645.856
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost					256.061	276.208	279.815	283.422	287.028	290.635
PC slab	strands					33	33	33	33	33	33
	wp (kg)					344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost					327.310	327.310	327.310	327.310	327.310	327.310
	anchorage					66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost					990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder					101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder					601.670	580.321	557.847	539.122	543.885	548.647
	Total					959.063	957.861	938.993	923.875	932.245	940.614
Transversal						79.9	79.8	78.2	77.0	77.7	78.4
Loss						103.9	103.8	101.7	100.1	101.0	101.9
Anchorage	general					570.0	540.0	510.0	480.0	480.0	480.0
	particular					114.0	108.0	102.0	96.0	96.0	96.0
Formwork						104.3	107.4	110.5	113.6	116.7	119.8
Labor	concrete					208.6	214.8	221.0	227.2	233.4	239.6
	steel					691.5	690.3	675.9	661.5	664.4	667.3
Transportation	USD/girder					51.1	52.7	54.2	55.6	57.2	58.7
Administration						1294.4	1294.9	1276.0	1259.5	1272.2	1285.0
Cost/girder	USD					3606.7	3609.5	3558.5	3514.4	3550.9	3587.3
Cost	USD					43280.1	43313.5	42701.5	42172.4	42610.5	43047.6
Girder setting	USD					666.53	675.96	684.91	693.85	703.29	712.23
Concrete joint	USD					874.37	874.37	874.37	874.37	874.37	874.37
Cost	USD					44821.0	44863.9	44260.8	43740.6	44188.2	44634.2

#	unit	G11 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2345	2420	2495	2570	2645	2720	2795	2870	2945	3020
Self-weight	ton	11.903	12.275	12.648	13.041	13.414	13.786	14.180	14.552	14.945	15.318
Total weight	ton	130.928	135.026	139.125	143.451	147.550	151.648	155.975	160.073	164.399	168.498
Ap	mm^2						1680	1680	1540	1540	1400
n	strands						12	12	11	11	10
Debonded	strands						10	9	9	8	8
	X1(m)						7.5	7.0	7.0	6.5	6.0
	length(m)						112.5	94.5	94.5	78.0	72.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost						56.250	47.250	47.250	39.000	36.000
Vc	m^3						5.630	5.786	5.941	6.096	6.251
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost						281.520	289.283	297.045	304.808	312.570
Wp	kg						272.992	272.992	250.242	250.242	227.493
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost						259.342	259.342	237.730	237.730	216.118
RC bars	kg						220.533	220.533	220.533	220.533	220.533
	kg						416.559	424.574	432.589	440.604	448.619
	total						637.092	645.107	653.122	661.137	669.152
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost						286.691	290.298	293.905	297.512	301.118
PC slab	strands						33	33	33	33	33
	wp (kg)						344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost						327.310	327.310	327.310	327.310	327.310
	anchorage						66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost						990.000	990.000	990.000	990.000	990.000
	cost/girder						101.332	101.332	101.332	101.332	101.332
Materials cost	Girder						597.112	595.875	582.025	581.538	564.688
	Total						985.135	987.504	977.261	980.381	967.138
Transversal							89.6	89.8	88.8	89.1	87.9
Loss							107.5	107.7	106.6	107.0	105.5
Anchorage	general						540.0	540.0	510.0	510.0	480.0
	particular						108.0	108.0	102.0	102.0	96.0
Formwork							112.6	115.7	118.8	121.9	125.0
Labor	concrete						225.2	231.4	237.6	243.8	250.1
	steel						698.7	701.6	687.2	690.0	675.6
Transportation	USD/girder						55.1	56.7	58.2	59.8	61.3
Administration							1331.5	1340.4	1327.0	1336.4	1321.1
Cost/girder	USD						3713.3	3738.8	3703.6	3730.4	3689.6
Cost	USD						40846.5	41126.9	40739.2	41034.8	40585.9
Girder setting	USD						633.30	641.95	650.15	658.80	667.00
Concrete joint	USD						794.88	794.88	794.88	794.88	794.88
Cost	USD						42274.7	42563.7	42184.2	42488.5	42047.8

#	unit	G10 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2489	2564	2639	2714	2789	2864	2939	3014	3089	3164
Self-weight	ton	12.627	13.000	13.393	13.766	14.138	14.531	14.904	15.277	15.670	16.043
Total weight	ton	126.270	129.996	133.929	137.655	141.381	145.314	149.040	152.766	156.699	160.425
Ap	mm^2							1820	1680	1540	1540
n	strands							13	12	11	11
Debonded	strands							10	9	8	8
	X1(m)							7.5	7.0	6.5	6.5
	length(m)							112.5	94.5	78.0	78.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost							56.250	47.250	39.000	39.000
Vc	m^3							6.084	6.239	6.394	6.549
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost							304.187	311.949	319.712	327.474
Wp	kg							295.741	272.992	250.242	250.242
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost							280.954	259.342	237.730	237.730
RC bars	kg							220.533	220.533	220.533	220.533
	kg							436.923	444.938	452.953	460.968
	total							657.456	665.471	673.486	681.501
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost							295.855	299.462	303.069	306.676
PC slab	strands							33	33	33	33
	wp (kg)							344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost							327.310	327.310	327.310	327.310
	anchorage							66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost							990.000	990.000	990.000	990.000
	cost/girder							101.332	101.332	101.332	101.332
Materials cost	Girder							641.390	618.541	596.442	604.204
	Total							1038.577	1019.335	1000.842	1012.211
Transversal								103.9	101.9	100.1	101.2
Loss								114.2	112.1	110.1	111.3
Anchorage	general							570.0	540.0	510.0	510.0
	particular							114.0	108.0	102.0	102.0
Formwork								121.7	124.8	127.9	131.0
Labor	concrete							243.3	249.6	255.8	262.0
	steel							723.3	708.9	694.5	697.4
Transportation	USD/girder							59.6	61.1	62.7	64.2
Administration								1406.9	1387.5	1368.6	1383.5
Cost/girder	USD							3925.5	3873.2	3822.5	3864.8
Cost	USD							39254.7	38732.3	38224.8	38647.5
Girder setting	USD							598.08	605.53	613.40	620.85
Concrete joint	USD							715.39	715.39	715.39	715.39
Cost	USD							40568.1	40053.2	39553.6	39983.8

#	unit	G09 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2615	2690	2765	2840	2915	2990	3065	3140	3215	3290
Self-weight	ton	13.269	13.641	14.014	14.407	14.780	15.173	15.546	15.918	16.312	16.684
Total weight	ton	119.418	122.772	126.125	129.665	133.018	136.558	139.911	143.265	146.804	150.158
Ap	mm^2								1820	1820	1680
n	strands								13	13	12
Debonded	strands								10	10	9
	X1(m)								8.0	7.5	7.0
	length(m)								120.0	112.5	94.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost								60.000	56.250	47.250
Vc	m^3								6.500	6.655	6.810
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost								324.990	332.753	340.515
Wp	kg								295.741	295.741	272.992
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost								280.954	280.954	259.342
RC bars	kg								220.533	220.533	220.533
	kg								508.016	516.031	524.046
	total								728.549	736.564	744.579
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost								327.847	331.454	335.060
PC slab	strands								33	33	33
	wp (kg)								344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost								327.310	327.310	327.310
	anchorage								66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost								990.000	990.000	990.000
	cost/girder								101.332	101.332	101.332
Materials cost	Girder								665.944	669.956	647.107
	Total								1095.122	1102.742	1083.499
Transversal									121.7	122.5	120.4
Loss									121.7	122.5	120.4
Anchorage	general								570.0	570.0	540.0
	particular								114.0	114.0	108.0
Formwork									130.0	133.1	136.2
Labor	concrete								260.0	266.2	272.4
	steel								748.9	751.8	737.4
Transportation	USD/girder								63.7	65.2	66.7
Administration									1481.8	1494.2	1474.7
Cost/girder	USD								4136.8	4172.3	4119.7
Cost	USD								37231.6	37550.9	37077.5
Girder setting	USD								556.53	563.61	570.32
Concrete joint	USD								794.88	794.88	794.88
Cost	USD								38583.0	38909.4	38442.7

#	unit	G08 f40									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2831	2906	2981	3056	3131	3206	3281	3356	3431	3506
Self-weight	ton	14.366	14.738	15.111	15.504	15.877	16.250	16.643	17.015	17.409	17.781
Total weight	ton	114.926	117.907	120.888	124.034	127.015	129.996	133.142	136.123	139.270	142.250
Ap	mm^2								1960	1820	1820
n	strands								14	13	13
Debonded	strands								10	10	9
	X1(m)								7.0	7.0	6.5
	length(m)								105.0	105.0	87.8
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost								52.500	52.500	43.875
Vc	m^3								6.947	7.102	7.257
	Unit cost	50	50	50	50	50	50	50	50	50	50
	cost								347.346	355.109	362.871
Wp	kg								318.490	295.741	295.741
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost								302.566	280.954	280.954
RC bars	kg								220.533	220.533	220.533
	kg								537.018	545.033	553.048
	total								757.551	765.566	773.581
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost								340.898	344.505	348.111
PC slab	strands								33	33	33
	wp (kg)								344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost								327.310	327.310	327.310
	anchorage								66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost								990.000	990.000	990.000
	cost/girder								101.332	101.332	101.332
Materials cost	Girder								702.412	688.562	687.700
	Total								1144.641	1134.398	1137.143
Transversal									143.1	141.8	142.1
Loss									128.8	127.6	127.9
Anchorage	general								600.0	570.0	570.0
	particular								120.0	114.0	114.0
Formwork									138.9	142.0	145.1
Labor	concrete								277.9	284.1	290.3
	steel								776.6	762.2	765.1
Transportation	USD/girder								68.1	69.6	71.1
Administration									1560.7	1547.1	1556.3
Cost/girder	USD								4358.7	4322.9	4349.2
Cost	USD								34869.5	34583.4	34793.5
Girder setting	USD								512.25	518.54	524.50
Concrete joint	USD								695.52	695.52	695.52
Cost	USD								36077.2	35797.4	36013.5

#	unit	G14 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2003	2078	2153	2228	2303	2378	2453	2528	2603	2678
Self-weight	ton	10.164	10.536	10.909	11.302	11.675	12.068	12.441	12.813	13.207	13.579
Total weight	ton	142.292	147.508	152.725	158.231	163.447	168.953	174.170	179.386	184.892	190.109
Ap	mm^2	1960	1820	1680	1540	1400	1260	1260	1260	1120	1120
n	strands	14	13	12	11	10	9	9	9	8	8
Debonded	strands	10	9	8	8	7	6	6	6	5	5
	X1(m)	5.5	5.5	5.0	5.0	4.5	4.0	4.0	3.5	3.5	3.5
	length(m)	82.5	74.3	60.0	60.0	47.3	36.0	36.0	31.5	26.3	26.3
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	41.250	37.125	30.000	30.000	23.625	18.000	18.000	15.750	13.125	13.125
Vc	m^3	4.146	4.301	4.457	4.612	4.767	4.922	5.078	5.233	5.388	5.543
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	248.773	258.088	267.403	276.718	286.033	295.348	304.663	313.978	323.293	332.608
Wp	kg	318.490	295.741	272.992	250.242	227.493	204.744	204.744	204.744	181.994	181.994
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	302.566	280.954	259.342	237.730	216.118	194.507	194.507	194.507	172.895	172.895
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	330.089	338.104	346.119	354.134	362.149	370.164	378.179	386.194	394.209	402.224
	total	513.867	521.882	529.897	537.912	545.927	590.697	598.712	606.727	614.742	622.757
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	231.240	234.847	238.454	242.060	245.667	265.814	269.421	273.027	276.634	280.241
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094	94.094
Materials cost	Girder	592.588	576.166	556.745	544.448	525.776	507.854	517.169	524.234	509.312	518.627
	Total	917.922	905.107	889.292	880.602	865.537	867.761	880.683	891.355	880.040	892.962
Transversal		65.6	64.7	63.5	62.9	61.8	62.0	62.9	63.7	62.9	63.8
Loss		98.3	97.0	95.3	94.4	92.7	93.0	94.4	95.5	94.3	95.7
Anchorage	general	600.0	570.0	540.0	510.0	480.0	450.0	450.0	450.0	420.0	420.0
	particular	120.0	114.0	108.0	102.0	96.0	90.0	90.0	90.0	84.0	84.0
Formwork		82.9	86.0	89.1	92.2	95.3	98.4	101.6	104.7	107.8	110.9
Labor	concrete	199.0	206.5	213.9	221.4	228.8	236.3	243.7	251.2	258.6	266.1
	steel	688.9	674.5	660.1	645.7	631.3	630.1	633.0	635.9	621.5	624.4
Transportation	USD/girder	40.7	42.1	43.6	45.2	46.7	48.3	49.8	51.3	52.8	54.3
Administration		1244.6	1230.4	1214.4	1202.9	1187.3	1190.7	1207.1	1222.0	1208.9	1225.2
Cost/girder	USD	3457.9	3420.3	3377.2	3347.2	3305.5	3316.6	3363.1	3405.5	3370.7	3417.3
Cost	USD	48410.9	47884.4	47281.4	46861.2	46277.4	46432.0	47083.4	47677.5	47190.5	47841.9
Girder setting	USD	704.58	715.02	725.45	736.46	746.89	757.91	768.34	778.77	789.78	800.22
Concrete joint	USD	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34	1033.34
Cost	USD	50148.8	49632.7	49040.2	48631.0	48057.6	48223.2	48885.1	49489.7	49013.6	49675.5

#	unit	G13 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2111	2186	2261	2336	2411	2486	2561	2636	2711	2786
Self-weight	ton	10.702	11.095	11.468	11.840	12.234	12.606	12.979	13.372	13.745	14.138
Total weight	ton	139.125	144.238	149.081	153.925	159.038	163.882	168.726	173.839	178.682	183.795
Ap	mm^2	2240	1960	1820	1680	1540	1400	1400	1260	1260	1260
n	strands	16	14	13	12	11	10	10	9	9	9
Debonded	strands	12	10	9	8	7	7	6	6	5	5
	X1(m)	5.5	5.5	5.5	5.0	5.0	4.5	4.0	4.0	3.5	3.5
	length(m)	99.0	82.5	74.3	60.0	52.5	47.3	36.0	36.0	26.3	26.3
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	49.500	41.250	37.125	30.000	26.250	23.625	18.000	18.000	13.125	13.125
Vc	m^3	4.370	4.525	4.680	4.836	4.991	5.146	5.301	5.457	5.612	5.767
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	262.186	271.501	280.816	290.131	299.446	308.761	318.076	327.391	336.706	346.021
Wp	kg	363.989	318.490	295.741	272.992	250.242	227.493	227.493	204.744	204.744	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	345.789	302.566	280.954	259.342	237.730	216.118	216.118	194.507	194.507	194.507
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	341.686	349.701	357.716	365.731	373.746	381.761	389.776	397.791	405.806	413.821
	total	525.463	533.478	541.493	549.508	557.523	602.294	610.309	618.324	626.339	634.354
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	236.459	240.065	243.672	247.279	250.885	271.032	274.639	278.246	281.852	285.459
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	657.476	615.317	598.895	579.473	563.426	548.505	552.195	539.898	544.338	553.653
	Total	995.266	956.714	943.899	928.083	915.643	920.868	928.165	919.475	927.522	940.443
Transversal		76.6	73.6	72.6	71.4	70.4	70.8	71.4	70.7	71.3	72.3
Loss		107.2	103.0	101.7	99.9	98.6	99.2	100.0	99.0	99.9	101.3
Anchorage	general	660.0	600.0	570.0	540.0	510.0	480.0	480.0	450.0	450.0	450.0
	particular	132.0	120.0	114.0	108.0	102.0	96.0	96.0	90.0	90.0	90.0
Formwork		87.4	90.5	93.6	96.7	99.8	102.9	106.0	109.1	112.2	115.3
Labor	concrete	209.7	217.2	224.7	232.1	239.6	247.0	254.5	261.9	269.4	276.8
	steel	727.6	696.0	681.5	667.1	652.7	651.6	654.5	640.0	642.9	645.8
Transportation	USD/girder	42.8	44.4	45.9	47.4	48.9	50.4	51.9	53.5	55.0	56.6
Administration		1337.2	1292.4	1278.2	1262.1	1248.1	1253.5	1266.3	1254.8	1268.0	1284.5
Cost/girder	USD	3715.8	3593.7	3556.0	3512.8	3475.8	3492.3	3528.7	3498.6	3536.3	3583.1
Cost	USD	48305.1	46718.7	46228.3	45666.4	45186.0	45400.1	45872.8	45481.6	45972.1	46579.7
Girder setting	USD	668.25	678.48	688.16	697.85	708.08	717.76	727.45	737.68	747.36	757.59
Concrete joint	USD	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86	953.86
Cost	USD	49927.2	48351.1	47870.3	47318.2	46847.9	47071.8	47554.1	47173.1	47673.3	48291.1

#	unit	G12 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2219	2294	2369	2444	2519	2594	2669	2744	2819	2894
Self-weight	ton	11.261	11.633	12.006	12.399	12.772	13.165	13.538	13.910	14.304	14.676
Total weight	ton	135.130	139.601	144.072	148.792	153.263	157.982	162.454	166.925	171.644	176.116
Ap	mm^2	2380	2240	1960	1820	1680	1540	1540	1400	1400	1260
n	strands	17	16	14	13	12	11	11	10	10	9
Debonded	strands	12	11	10	9	8	7	7	6	6	5
	X1(m)	5.5	5.5	5.5	5.5	5.0	4.5	4.5	4.0	4.0	3.5
	length(m)	99.0	90.8	82.5	74.3	60.0	47.3	47.3	36.0	36.0	26.3
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	49.500	45.375	41.250	37.125	30.000	23.625	23.625	18.000	18.000	13.125
Vc	m^3	4.593	4.749	4.904	5.059	5.214	5.370	5.525	5.680	5.835	5.991
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	275.600	284.915	294.230	303.545	312.860	322.175	331.490	340.805	350.120	359.435
Wp	kg	386.738	363.989	318.490	295.741	272.992	250.242	250.242	227.493	227.493	204.744
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	367.401	345.789	302.566	280.954	259.342	237.730	237.730	216.118	216.118	194.507
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	353.188	361.203	369.218	377.233	385.248	393.263	401.278	409.293	417.308	425.323
	total	536.965	544.980	552.995	561.010	569.025	613.796	621.811	629.826	637.841	645.856
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	241.634	245.241	248.848	252.455	256.061	276.208	279.815	283.422	287.028	290.635
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	692.501	676.079	638.045	621.624	602.202	583.530	592.845	574.923	584.238	567.066
	Total	1035.467	1022.652	988.225	975.410	959.595	961.070	973.991	959.676	972.598	959.033
Transversal		86.3	85.2	82.4	81.3	80.0	80.1	81.2	80.0	81.0	79.9
Loss		112.2	110.8	107.1	105.7	104.0	104.1	105.5	104.0	105.4	103.9
Anchorage	general	690.0	660.0	600.0	570.0	540.0	510.0	510.0	480.0	480.0	450.0
	particular	138.0	132.0	120.0	114.0	108.0	102.0	102.0	96.0	96.0	90.0
Formwork		91.9	95.0	98.1	101.2	104.3	107.4	110.5	113.6	116.7	119.8
Labor	concrete	220.5	227.9	235.4	242.8	250.3	257.7	265.2	272.6	280.1	287.5
	steel	749.1	734.7	703.0	688.6	674.2	673.0	675.9	661.5	664.4	650.0
Transportation	USD/girder	45.0	46.5	48.0	49.6	51.1	52.7	54.2	55.6	57.2	58.7
Administration		1392.7	1378.5	1336.2	1322.0	1305.8	1308.8	1325.2	1310.0	1326.5	1311.8
Cost/girder	USD	3871.1	3833.2	3718.3	3680.5	3637.1	3646.8	3693.6	3653.0	3699.9	3660.6
Cost	USD	46453.3	45998.9	44619.7	44166.3	43645.6	43762.1	44323.6	43836.1	44398.6	43927.6
Girder setting	USD	630.26	639.20	648.14	657.58	666.53	675.96	684.91	693.85	703.29	712.23
Concrete joint	USD	874.37	874.37	874.37	874.37	874.37	874.37	874.37	874.37	874.37	874.37
Cost	USD	47957.9	47512.4	46142.2	45698.2	45186.5	45312.4	45882.9	45404.3	45976.3	45514.2

#	unit	G11 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2345	2420	2495	2570	2645	2720	2795	2870	2945	3020
Self-weight	ton	11.903	12.275	12.648	13.041	13.414	13.786	14.180	14.552	14.945	15.318
Total weight	ton	130.928	135.026	139.125	143.451	147.550	151.648	155.975	160.073	164.399	168.498
Ap	mm^2	2520	2240	2100	1960	1820	1680	1540	1540	1400	1400
n	strands	18	16	15	14	13	12	11	11	10	10
Debonded	strands	13	11	10	9	9	8	7	7	6	6
	X1(m)	6.0	6.0	6.0	5.5	5.0	5.0	4.5	4.0	4.0	3.5
	length(m)	117.0	99.0	90.0	74.3	67.5	60.0	47.3	42.0	36.0	31.5
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	58.500	49.500	45.000	37.125	33.750	30.000	23.625	21.000	18.000	15.750
Vc	m^3	4.854	5.009	5.165	5.320	5.475	5.630	5.786	5.941	6.096	6.251
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	291.249	300.564	309.879	319.194	328.509	337.824	347.139	356.454	365.769	375.084
Wp	kg	409.487	363.989	341.240	318.490	295.741	272.992	250.242	250.242	227.493	227.493
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	389.013	345.789	324.178	302.566	280.954	259.342	237.730	237.730	216.118	216.118
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	376.484	384.499	392.514	400.529	408.544	416.559	424.574	432.589	440.604	448.619
	total	560.261	568.276	576.291	584.306	592.321	637.092	645.107	653.122	661.137	669.152
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	252.118	255.724	259.331	262.938	266.545	286.691	290.298	293.905	297.512	301.118
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	738.762	695.853	679.057	658.885	643.213	627.166	608.494	615.184	599.887	606.952
	Total	1092.211	1052.909	1039.719	1023.154	1011.089	1015.189	1000.124	1010.420	998.730	1009.402
Transversal		99.3	95.7	94.5	93.0	91.9	92.3	90.9	91.9	90.8	91.8
Loss		119.2	114.9	113.4	111.6	110.3	110.7	109.1	110.2	109.0	110.1
Anchorage	general	720.0	660.0	630.0	600.0	570.0	540.0	510.0	510.0	480.0	480.0
	particular	144.0	132.0	126.0	120.0	114.0	108.0	102.0	102.0	96.0	96.0
Formwork		97.1	100.2	103.3	106.4	109.5	112.6	115.7	118.8	121.9	125.0
Labor	concrete	233.0	240.5	247.9	255.4	262.8	270.3	277.7	285.2	292.6	300.1
	steel	774.8	743.1	728.7	714.3	699.8	698.7	684.3	687.2	672.8	675.6
Transportation	USD/girder	47.6	49.1	50.6	52.2	53.7	55.1	56.7	58.2	59.8	61.3
Administration		1464.2	1418.6	1404.1	1387.3	1373.5	1378.2	1362.4	1377.2	1363.7	1378.7
Cost/girder	USD	4071.3	3946.9	3908.2	3863.3	3826.6	3841.1	3799.0	3841.1	3805.2	3848.0
Cost	USD	44784.3	43415.7	42989.7	42495.8	42092.8	42252.4	41789.0	42252.1	41857.6	42328.3
Girder setting	USD	591.86	600.05	608.25	616.90	625.10	633.30	641.95	650.15	658.80	667.00
Concrete joint	USD	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88
Cost	USD	46171.0	44810.7	44392.9	43907.6	43512.7	43680.6	43225.9	43697.1	43311.3	43790.2

#	unit	G10 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2489	2564	2639	2714	2789	2864	2939	3014	3089	3164
Self-weight	ton	12.627	13.000	13.393	13.766	14.138	14.531	14.904	15.277	15.670	16.043
Total weight	ton	126.270	129.996	133.929	137.655	141.381	145.314	149.040	152.766	156.699	160.425
Ap	mm^2	2800	2520	2240	2100	1960	1820	1680	1680	1540	1540
n	strands	20	18	16	15	14	13	12	12	11	11
Debonded	strands	14	13	11	10	9	8	7	7	6	6
	X1(m)	6.0	6.0	6.0	5.5	5.5	5.0	5.0	4.5	4.0	4.0
	length(m)	126.0	117.0	99.0	82.5	74.3	60.0	52.5	47.3	36.0	36.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	63.000	58.500	49.500	41.250	37.125	30.000	26.250	23.625	18.000	18.000
Vc	m^3	5.152	5.307	5.463	5.618	5.773	5.928	6.084	6.239	6.394	6.549
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	309.134	318.449	327.764	337.079	346.394	355.709	365.024	374.339	383.654	392.969
Wp	kg	454.986	409.487	363.989	341.240	318.490	295.741	272.992	272.992	250.242	250.242
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	432.237	389.013	345.789	324.178	302.566	280.954	259.342	259.342	237.730	237.730
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	388.833	396.848	404.863	412.878	420.893	428.908	436.923	444.938	452.953	460.968
	total	572.611	580.626	588.641	596.656	604.671	649.441	657.456	665.471	673.486	681.501
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	257.675	261.282	264.888	268.495	272.102	292.249	295.855	299.462	303.069	306.676
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	804.371	765.962	723.053	702.506	686.084	666.663	650.616	657.306	639.384	648.699
	Total	1163.377	1128.575	1089.273	1072.333	1059.518	1060.243	1047.803	1058.099	1043.784	1056.706
Transversal		116.3	112.9	108.9	107.2	106.0	106.0	104.8	105.8	104.4	105.7
Loss		128.0	124.1	119.8	118.0	116.5	116.6	115.3	116.4	114.8	116.2
Anchorage	general	780.0	720.0	660.0	630.0	600.0	570.0	540.0	540.0	510.0	510.0
	particular	156.0	144.0	132.0	126.0	120.0	114.0	108.0	108.0	102.0	102.0
Formwork		103.0	106.1	109.3	112.4	115.5	118.6	121.7	124.8	127.9	131.0
Labor	concrete	247.3	254.8	262.2	269.7	277.1	284.6	292.0	299.5	306.9	314.4
	steel	813.8	782.1	750.4	736.0	721.6	720.4	706.0	708.9	694.5	697.4
Transportation	USD/girder	50.5	52.0	53.6	55.1	56.6	58.1	59.6	61.1	62.7	64.2
Administration		1559.9	1517.1	1471.2	1454.1	1439.8	1442.3	1428.2	1443.0	1427.7	1444.3
Cost/girder	USD	4338.2	4221.6	4096.7	4050.7	4012.5	4020.9	3983.3	4025.6	3984.6	4031.8
Cost	USD	43382.3	42216.2	40966.8	40507.4	40125.1	40208.5	39833.3	40255.8	39846.3	40317.9
Girder setting	USD	552.54	559.99	567.86	575.31	582.76	590.63	598.08	605.53	613.40	620.85
Concrete joint	USD	715.39	715.39	715.39	715.39	715.39	715.39	715.39	715.39	715.39	715.39
Cost	USD	44650.2	43491.6	42250.1	41798.1	41423.2	41514.6	41146.7	41576.7	41175.1	41654.1

#	unit	G09 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2615	2690	2765	2840	2915	2990	3065	3140	3215	3290
Self-weight	ton	13.269	13.641	14.014	14.407	14.780	15.173	15.546	15.918	16.312	16.684
Total weight	ton	119.418	122.772	126.125	129.665	133.018	136.558	139.911	143.265	146.804	150.158
Ap	mm^2	3360	2800	2520	2240	2100	1960	1820	1820	1680	1680
n	strands	24	20	18	16	15	14	13	13	12	12
Debonded	strands	15	14	12	11	10	9	8	8	7	7
	X1(m)	4.5	6.0	6.5	6.5	6.0	5.5	5.5	5.0	4.5	4.0
	length(m)	101.3	126.0	117.0	107.3	90.0	74.3	66.0	60.0	47.3	42.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	50.625	63.000	58.500	53.625	45.000	37.125	33.000	30.000	23.625	21.000
Vc	m^3	5.413	5.568	5.724	5.879	6.034	6.189	6.345	6.500	6.655	6.810
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	324.783	334.098	343.413	352.728	362.043	371.358	380.673	389.988	399.303	408.618
Wp	kg	545.983	454.986	409.487	363.989	341.240	318.490	295.741	295.741	272.992	272.992
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	518.684	432.237	389.013	345.789	324.178	302.566	280.954	280.954	259.342	259.342
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	451.911	459.926	467.941	475.956	483.971	491.986	500.001	508.016	516.031	524.046
	total	635.688	643.703	651.718	659.733	667.748	712.519	720.534	728.549	736.564	744.579
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	286.060	289.666	293.273	296.880	300.487	320.633	324.240	327.847	331.454	335.060
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	894.092	829.335	790.926	752.142	731.221	711.049	694.627	700.942	682.270	688.960
	Total	1281.483	1220.333	1185.531	1150.354	1133.039	1133.014	1120.199	1130.120	1115.055	1125.352
Transversal		142.4	135.6	131.7	127.8	125.9	125.9	124.5	125.6	123.9	125.0
Loss		142.4	135.6	131.7	127.8	125.9	125.9	124.5	125.6	123.9	125.0
Anchorage	general	900.0	780.0	720.0	660.0	630.0	600.0	570.0	570.0	540.0	540.0
	particular	180.0	156.0	144.0	132.0	126.0	120.0	114.0	114.0	108.0	108.0
Formwork		108.3	111.4	114.5	117.6	120.7	123.8	126.9	130.0	133.1	136.2
Labor	concrete	259.8	267.3	274.7	282.2	289.6	297.1	304.5	312.0	319.4	326.9
	steel	905.6	839.4	807.7	776.0	761.6	760.4	746.0	748.9	734.5	737.4
Transportation	USD/girder	53.1	54.6	56.1	57.6	59.1	60.7	62.2	63.7	65.2	66.7
Administration		1726.6	1638.0	1594.9	1551.5	1534.1	1536.1	1521.7	1536.3	1520.4	1535.3
Cost/girder	USD	4799.6	4558.1	4440.8	4322.9	4275.9	4282.9	4244.4	4286.1	4243.5	4286.0
Cost	USD	43196.6	41022.6	39967.2	38906.2	38483.4	38545.9	38199.6	38575.3	38191.6	38573.6
Girder setting	USD	508.84	515.54	522.25	529.33	536.04	543.12	549.82	556.53	563.61	570.32
Concrete joint	USD	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88	794.88
Cost	USD	44500.3	42333.0	41284.3	40230.4	39814.3	39883.9	39544.3	39926.7	39550.0	39938.8

#	unit	G08 f80									
h	cm	75	80	85	90	95	100	105	110	115	120
A	cm^2	2831	2906	2981	3056	3131	3206	3281	3356	3431	3506
Self-weight	ton	14.366	14.738	15.111	15.504	15.877	16.250	16.643	17.015	17.409	17.781
Total weight	ton	114.926	117.907	120.888	124.034	127.015	129.996	133.142	136.123	139.270	142.250
Ap	mm^2	3640	2940	2520	2380	2240	2100	1960	1820	1820	1680
n	strands	26	21	18	17	16	15	14	13	13	12
Debonded	strands	16	14	12	11	10	9	8	8	7	6
	X1(m)	7.5	5.5	6.5	6.0	5.5	5.0	5.0	4.5	4.0	4.0
	length(m)	180.0	115.5	117.0	99.0	82.5	67.5	60.0	54.0	42.0	36.0
	Unit cost	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	cost	90.000	57.750	58.500	49.500	41.250	33.750	30.000	27.000	21.000	18.000
Vc	m^3	5.860	6.015	6.171	6.326	6.481	6.636	6.792	6.947	7.102	7.257
	Unit cost	60	60	60	60	60	60	60	60	60	60
	cost	351.610	360.925	370.240	379.555	388.870	398.185	407.500	416.815	426.130	435.445
Wp	kg	591.482	477.735	409.487	386.738	363.989	341.240	318.490	295.741	295.741	272.992
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	561.908	453.849	389.013	367.401	345.789	324.178	302.566	280.954	280.954	259.342
RC bars	kg	183.778	183.778	183.778	183.778	183.778	220.533	220.533	220.533	220.533	220.533
	kg	480.913	488.928	496.943	504.958	512.973	520.988	529.003	537.018	545.033	553.048
	total	664.690	672.705	680.720	688.735	696.750	741.521	749.536	757.551	765.566	773.581
	Unit cost	450	450	450	450	450	450	450	450	450	450
	cost	299.111	302.717	306.324	309.931	313.538	333.684	337.291	340.898	344.505	348.111
PC slab	strands	33	33	33	33	33	33	33	33	33	33
	wp (kg)	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5	344.5
	Unit cost	950	950	950	950	950	950	950	950	950	950
	cost	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310	327.310
	anchorage	66	66	66	66	66	66	66	66	66	66
	Unit cost	15	15	15	15	15	15	15	15	15	15
	cost	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000	990.000
	cost/girder	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332	101.332
Materials cost	Girder	1003.518	872.524	817.753	796.456	775.910	756.113	740.066	724.769	728.084	712.787
	Total	1403.960	1276.573	1225.409	1207.719	1190.779	1191.129	1178.688	1166.998	1173.920	1162.230
Transversal		175.5	159.6	153.2	151.0	148.8	148.9	147.3	145.9	146.7	145.3
Loss		157.9	143.6	137.9	135.9	134.0	134.0	132.6	131.3	132.1	130.8
Anchorage	general	960.0	810.0	720.0	690.0	660.0	630.0	600.0	570.0	570.0	540.0
	particular	192.0	162.0	144.0	138.0	132.0	126.0	120.0	114.0	114.0	108.0
Formwork		117.2	120.3	123.4	126.5	129.6	132.7	135.8	138.9	142.0	145.1
Labor	concrete	281.3	288.7	296.2	303.6	311.1	318.5	326.0	333.5	340.9	348.4
	steel	950.7	867.1	818.1	803.7	789.3	788.1	773.7	759.3	762.2	747.8
Transportation	USD/girder	57.5	59.0	60.4	62.0	63.5	65.0	66.6	68.1	69.6	71.1
Administration		1872.4	1724.6	1656.2	1638.3	1621.0	1623.3	1609.0	1595.2	1607.9	1594.1
Cost/girder	USD	5208.4	4801.4	4614.8	4566.8	4520.1	4527.7	4489.7	4453.1	4489.4	4452.8
Cost	USD	41667.1	38411.5	36918.4	36534.2	36160.9	36221.5	35917.8	35624.8	35915.3	35622.4
Girder setting	USD	469.85	475.81	481.78	488.07	494.03	499.99	506.28	512.25	518.54	524.50
Concrete joint	USD	695.52	695.52	695.52	695.52	695.52	695.52	695.52	695.52	695.52	695.52
Cost	USD	42832.4	39582.8	38095.7	37717.8	37350.5	37417.1	37119.6	36832.5	37129.4	36842.4