DESIGN OF PRESTRESSED CONCRETE GIRDER FOR BRIDGE REHABILITATION AND CONSTRUCTION IN DEVELOPING COUNTRIES

H. Shima[1] and S. Vong[2]

1) Dr. Eng., Professor, Infrastructure System Engineering, Kochi University of Technology, Japan;
E-mail: shima.hiroshi@kochi-tech .ac.jp

2) Ph.D., Infrastructure System Engineering, Kochi University of Technology, Japan
Email: seng@itc.edu.kh

ABSTRACT:

The development of infrastructures in developing countries requires innovations in specific technology which are applicable to their local environments. For the particular case of bridge rehabilitation and construction, a quick system for construction should be set up with the conditions of economic and durability. An appropriable technology for bridge rehabilitation and construction would be pre-cast pre-stressed concrete (PC). However, most developing countries do not have their own local standard on the design and construction of PC girders. And, many of the existing road and bridge structures have lower load bearing capacity which inhibit the design of heavy PC girders.

Therefore, in this study the design method is presented. The design for the PC girder to be done to satisfy the requirements of the developing countries including their own situation with the considerations of local materials, equipment, traffic load and climate has been explained.

KEYWORDS: Local standard PC girder, Bridge rehabilitation and construction, developing countries.

1. INTRODUCTION

To obtain the appropriate PC girder for use in the developing countries, the design should include the production step, transportation step and construction step with the considerations of specific design factors of their own environment such as local materials, traffic, access road to the construction site, climate and equipment. And standard PC girder can be determined by the conditions of self-weight of girder and total cost of bridge superstructure.

Self-weight of PC girder has to be limited by the conditions of moving the girders for construction and transportation with consideration of access road to the construction site. When thin section and high strength concrete are required to satisfy the design and production conditions, the selection of concrete type used for producing PC girder is very important to ensure the production quality. Self-compacting concrete (SCC) which can flow under its own weight and completely fill a formwork even in the presence of dense reinforcement without requiring any vibration gives high strength in stable condition. SCC thus can satisfy the required concrete quality to produce the suitable PC girder with thin section for high strength. The authors studied the method to produce SCC in the developing countries for a case of Cambodia [1].

2. DESIGN METHOD

The appropriate self-weight of PC girder for use in the environment of developing countries can be determined by the combination of:

- Determining the shape of section
- Using high strength of concrete
- Applying high prestressing force
- Determining the number of girders
- Considering the bond control case: the prestressing force can be applied at largest eccentricity.

In order to satisfy these conditions, the calculation has to be made by:

- Choosing the different girder shapes (box-shape, T-shape)
- Varying the number of girders
- Varying the height of girders
- Varying the concrete strength
- Estimating the bridge superstructure costs for each case

Based on the proposed method above, the bridge superstructure costs and the limit of self-weight of girder can determine standard PC girder for use in developing countries.

The application of this design method for the case of Cambodia is explained in the followings [2]. The calculation was made on the typical one and half lane bridges as shown in Figure 1 to determine the section shape. Dimensions of T-shape and box shape girders are chosen as in Figure 2. The heights of girders were determined to be the optimum for each case. The span was varied as 10, 15, 20 and 25 meters. Basic design concrete strength was varied as 45MPa, 60MPa and 75MPa. The traffic load (load type A) given in Japanese standard for bridge design was used.

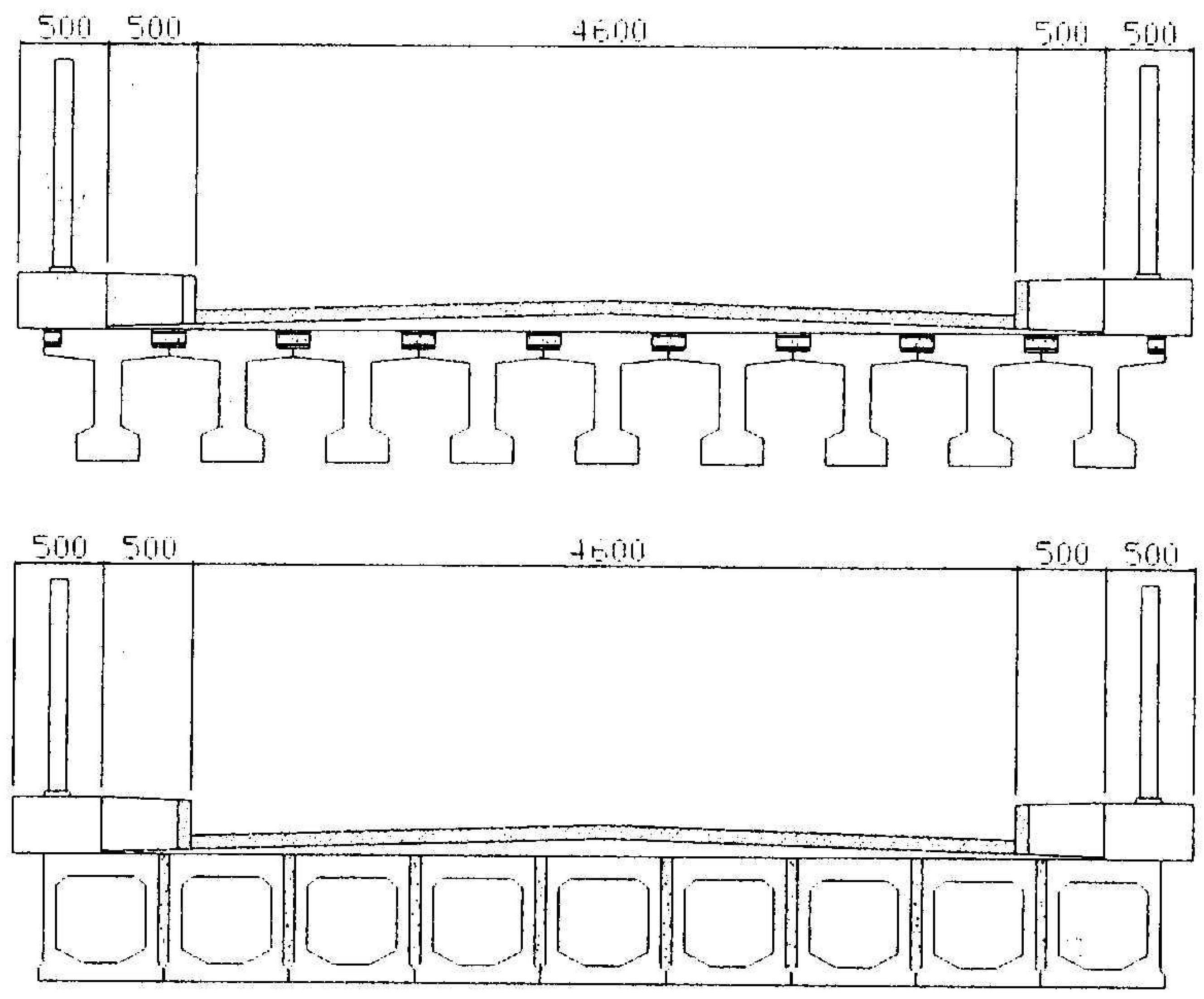

Figure 1: Typical one lane bridge of T-shape and box shape girders

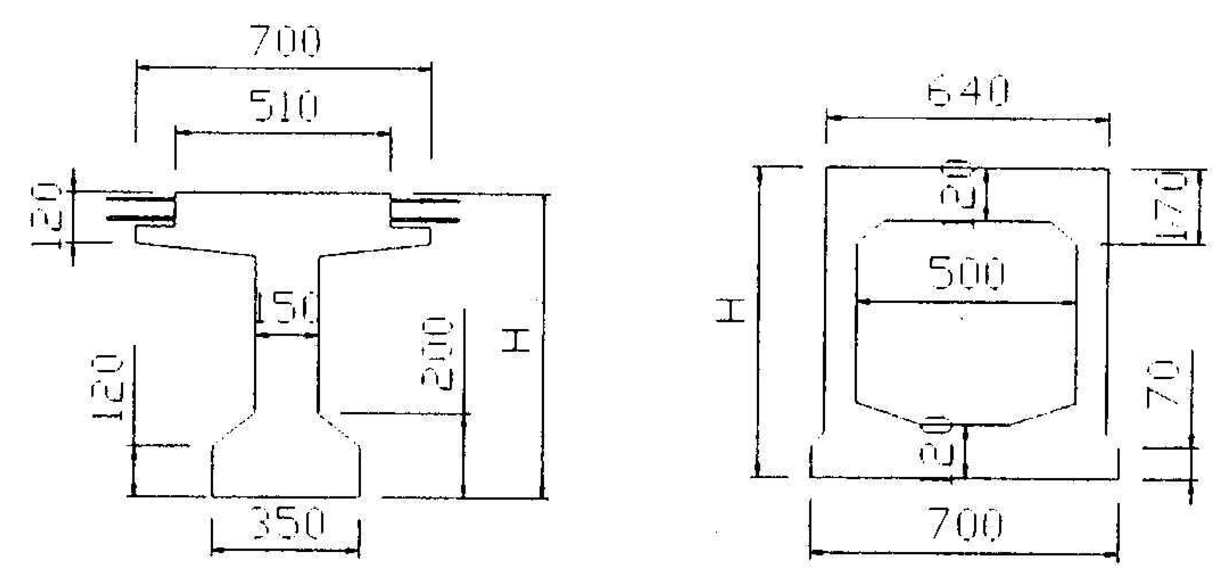

Figure 2: Dimensions of T-shape and box shape girders

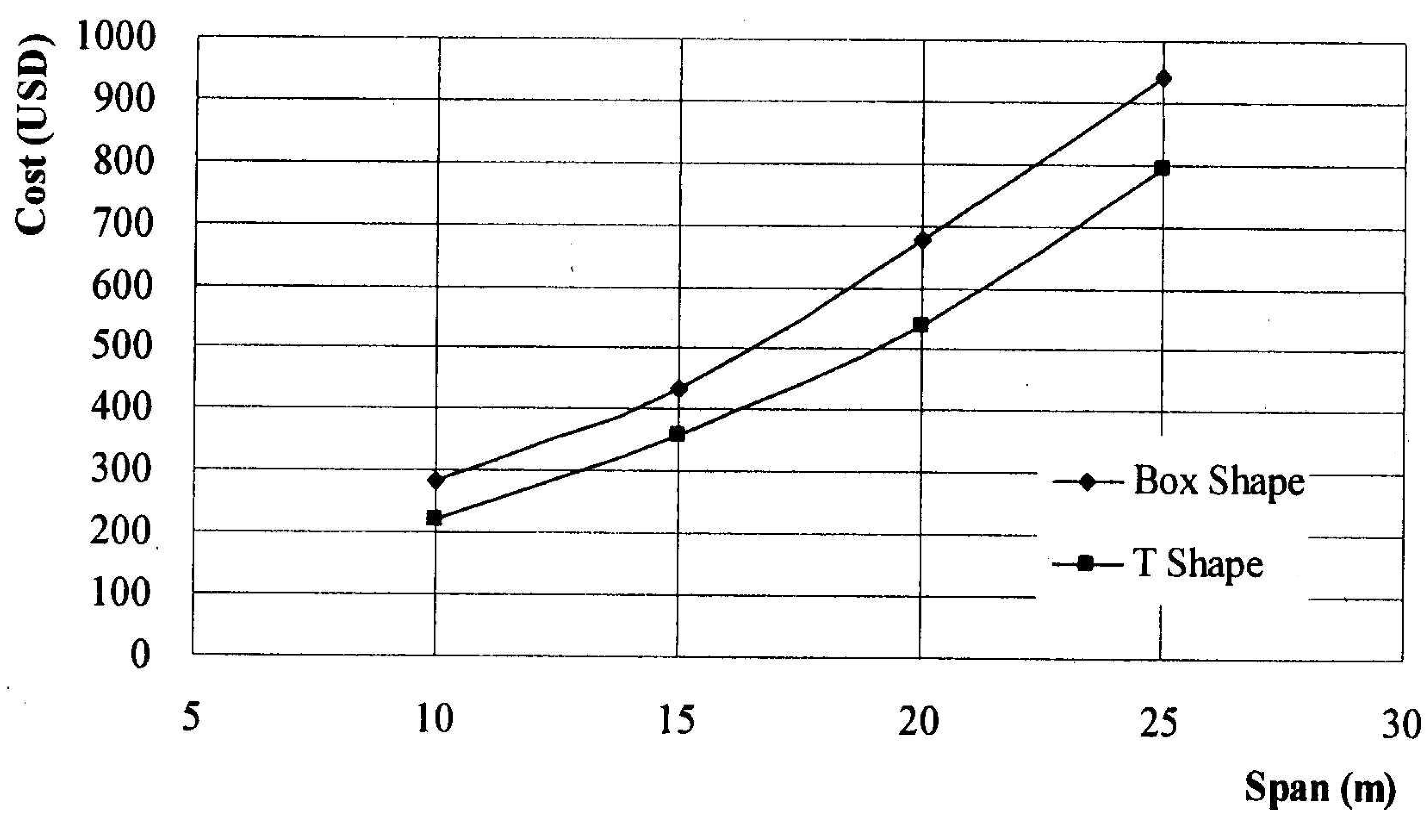

Figure 3: Material cost of girders for the case of concrete strength 60MPa

Only the cost of concrete and PC strands is taken into account for the material cost shown in the graphic of Figure 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.

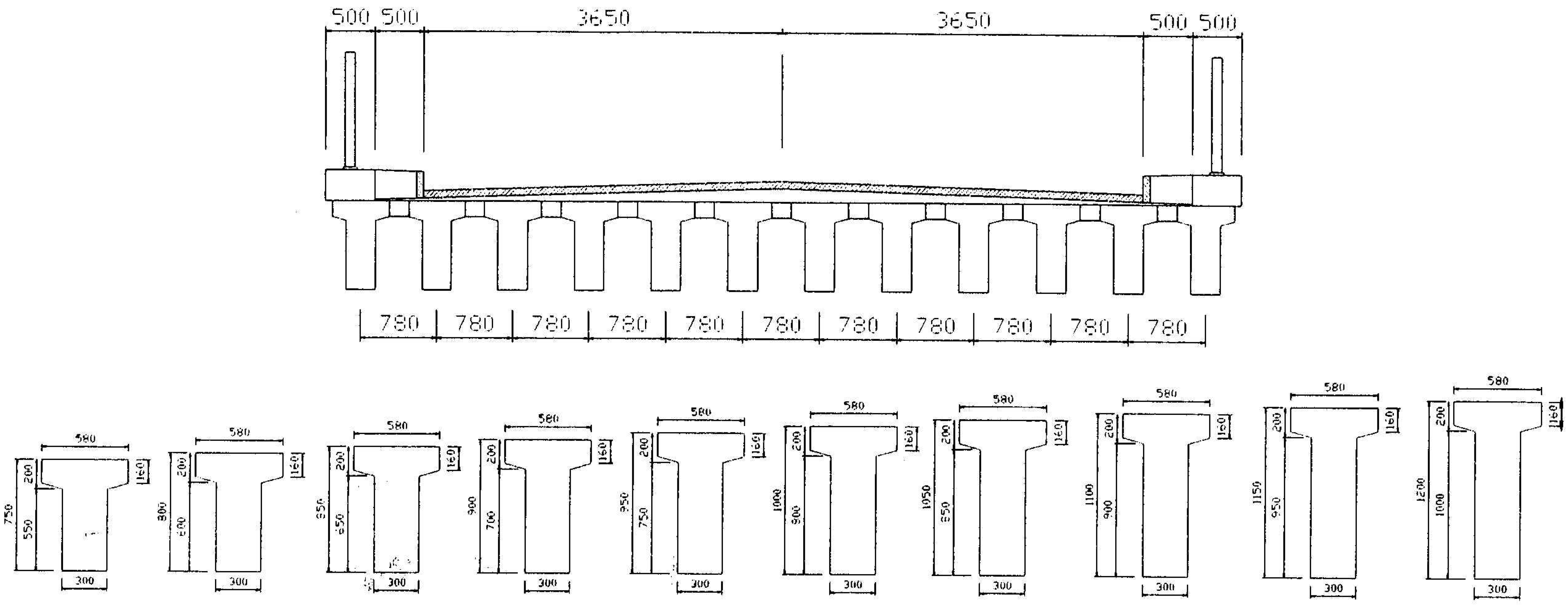

Figure 4: Typical two lanes girder bridge of T-shape

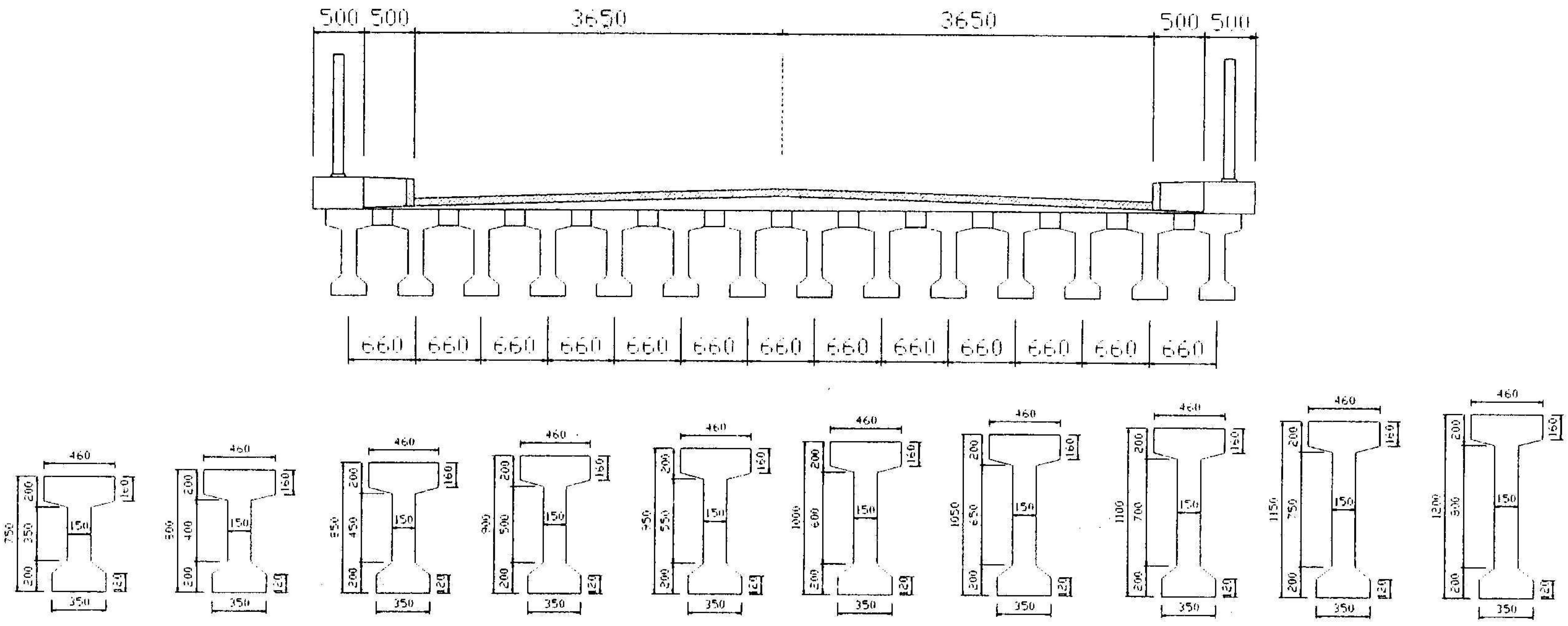

Figure 5: Typical two lanes girder bridge of T-shape with heavy bottom flange

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 Figure 4 and Figure 5 were designed by:

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

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.

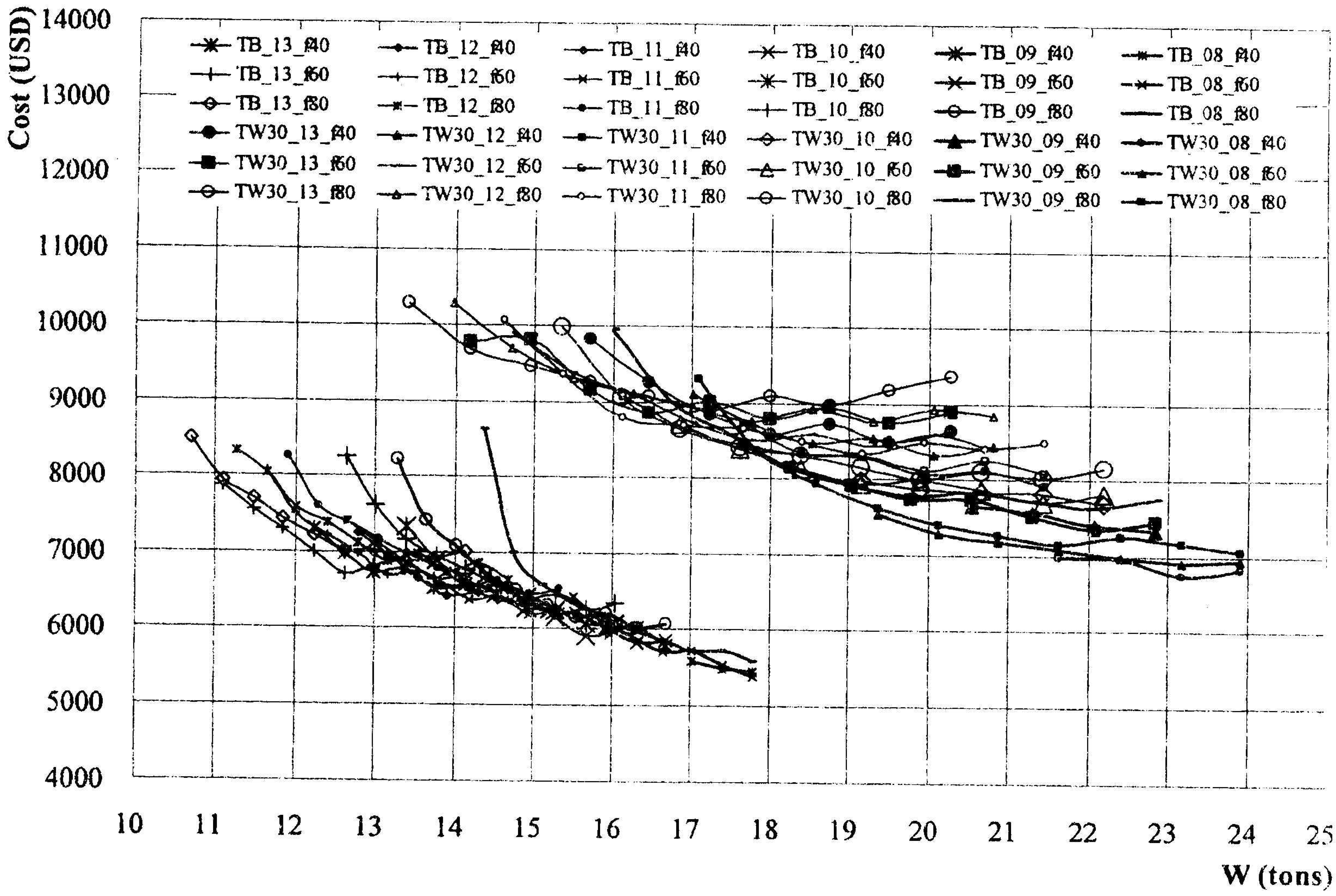

Figure 6: Material cost of bridge superstructure

The results are represented on the graphic of Figure 6. Based on this graphic T-shape with heavy bottom flange is selected.

3. STANDARD PRESTRESSED CONCRETE BRIDGE GIRDER

The total cost of bridge superstructures were calculated for each case. With the limitation of its self-weight, the standard precast PC girder can be determined by using the graphic shown in Figure 7. 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 Figure 8.

For the selected girder, the total prestressing force just after transfer is 2000kN and its eccentricity is 402.2mm. Bond control is required.

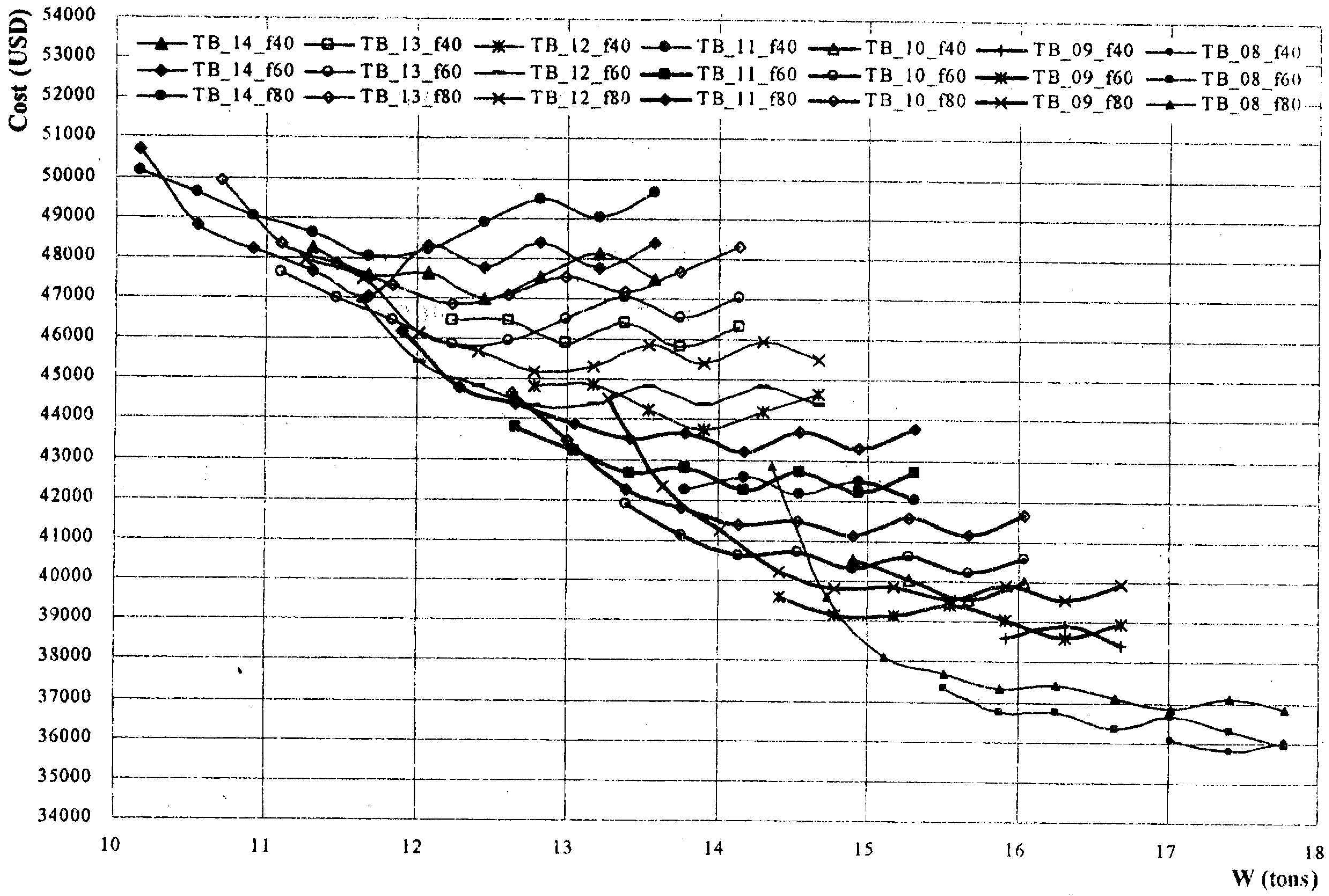

Figure 7: Total cost of bridge superstructure

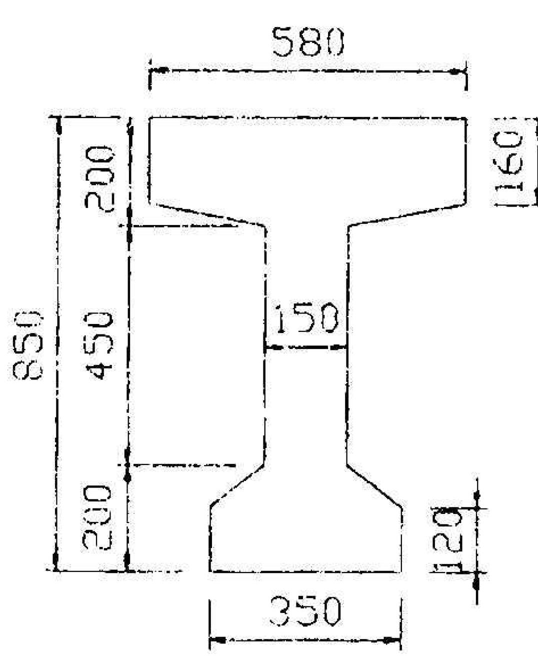

Figure 8: Selected girders

4. CONCLUSIONS

The appropriate weight of girder which is suitable for the developing countries situation can be made by the combination of:

- Determining the section shape
- Using high strength concrete
- Applying high prestressing force
- Minimizing the dimensions of section by increasing the number of girders

Thus, standard PC girder for developing countries can be determined by the proposed method.

5. REFERENCES

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