

PRECAST ELEMENTS IN BRIDGE CONSTRUCTION

Damir Tkalcic, BSc, Civil Engineering Institute of Croatia, Zagreb, Croatia

Petar Sesar, MSc, Civil Engineering Institute of Croatia, Zagreb, Croatia

Ana Krecak, BSc, Civil Engineering Institute of Croatia, Zagreb, Croatia

ABSTRACT

The future Bregana-Zagreb-Dubrovnik motorway is the biggest construction site in Croatia and is of great importance, both for the country itself and as part of the route from Central Europe to its south, and further on to Greece and Turkey.

That's why it is of a vital importance for all structures along the motorway to be built as fast as possible. Building with precast elements is the most suitable way to do it so.

This paper will show organizational and productional process and problems that occur during production of precast elements in big constructional project such as construction of motorways. It will furthermore give some recommendations for improvement of precast element production and its organizational incorporation into the whole construction project.

Some observations of bridge construction made of precast elements, not concerning only precast girders but also precast piers, foundations and some other structural parts that are being produced as precast will be presented.

Attention will be given to the process of production of precast elements (either in concrete factory on construction site or in concrete plant), industrialization of production, transport of precast elements, their installation in one entirety and maintenance of the precast parts in structures exploitation.

Keywords: Precast Elements, Fast Construction, Production of Precast Elements

INTRODUCTION

Croatia is the biggest construction site among European transition countries. In June 2003 approximately 125 km of motorways will be opened to traffic, which is only a part of country's plan for motorway development in the next three years.

Our company Civil Engineering Institute of Croatia is one of major contributors to this construction project as designers, supervision and quality control managers. This project named "The Croatian Motorway Project" is run by American company "Bechtel" in cooperation with Croatian building companies. Construction of structures constructed of precast elements (such as bridges, viaducts, and smaller structures like culverts, overpasses and underpasses) on sections of Bregana – Zagreb – Dubrovnik motorway which were designed in Civil Engineering Institute of Croatia will be presented in this paper.



Figure 1: Map of Croatian Motorways

Due to country's vital interest to complete construction of motorways as fast as possible, especially those along the coast, it was quite a challenge for structural designers to design structures that would be built in a short period of time and also meet requirements they need to fulfill. The most suitable way to do it is to design structures made of precast elements.

Bridges and viaducts designed in Bridge Division of the Civil Engineering Institute of Croatia are designed mostly as structures with superstructures made of precast elements.

CONSTRUCTION WITH PRECAST ELEMENTS

Standardization of structures in motorway project, construction time and quantity of works which are currently under way in Croatia require construction with precast elements. All structures on motorways, except special structures (cable-stayed bridges, arch bridges etc.), are designed to be built with precast elements. It mostly means that parts of superstructure are precast (girders, New Jersey elements, cornices, curb stone elements etc.), while all substructure parts are in most cases cast in situ. It is however possible to build substructure's parts of precast elements (piers, pier foundations), but it wasn't the case here.

The clients requirements are usually for structures to be designed and constructed in a manner that enables easy maintenance and repair. This results in standard superstructures used for most of the bridges and other structures. Although this seems to make easier the designers job, it is sometimes very hard to implement same type of precast girders on any obstacle along the highway route.

Structural systems that are constructed using precast girders can be divided in two groups:

- simple supported
- continuous structural systems.

Construction principle of both systems is similar. The main difference is in a manner of achieving continuity above piers.

At simple supported structural systems continuity above supports is achieved with link slab. Link slab is thinner than deck slab (Fig.2) because it has to bear different rotation angles caused by outside loadings. Therefore, the probability of crack occurrence at the connection between the girders and the link slabs is minimized. Special attention is given to waterproofing on link slabs because of possible concentration of cracks. Waterproofing is done in at least two layers with special grounding underneath.

Link slab is reinforced with reinforcement needed for loads and strengthened on edges. Strengthening is done with two cross-girders at the supports. These girders are made with special reinforcement shaping. Link slab reinforcement is overlapped with deck slab reinforcement.

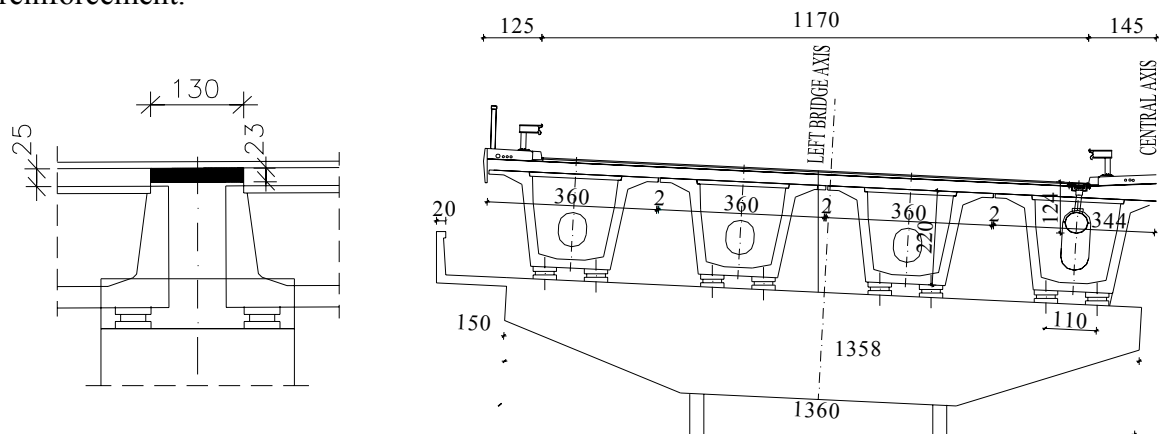


Figure 2: Continuity above pier – simple supported static system

Disadvantage of simple supported system is a number of bearings needed, especially for box girders which are placed on four bearings each. Any difference in bearing bed height on site would cause unfavorable torsion effects. Therefore special attention has to be given to girder placing. It is crucial to say that these kinds of structures are not so sensible to differential settlement of the grounds.

At continuous static systems continuity at supports is achieved with sinking of longitudinal girders in cross-girders. Superstructure is than supported on two or three bearings and is not so sensible to differences between neighboring bearing beds. The disadvantages of this static system are that they are very sensible to differential ground settlement and appearance of negative moments on supports.

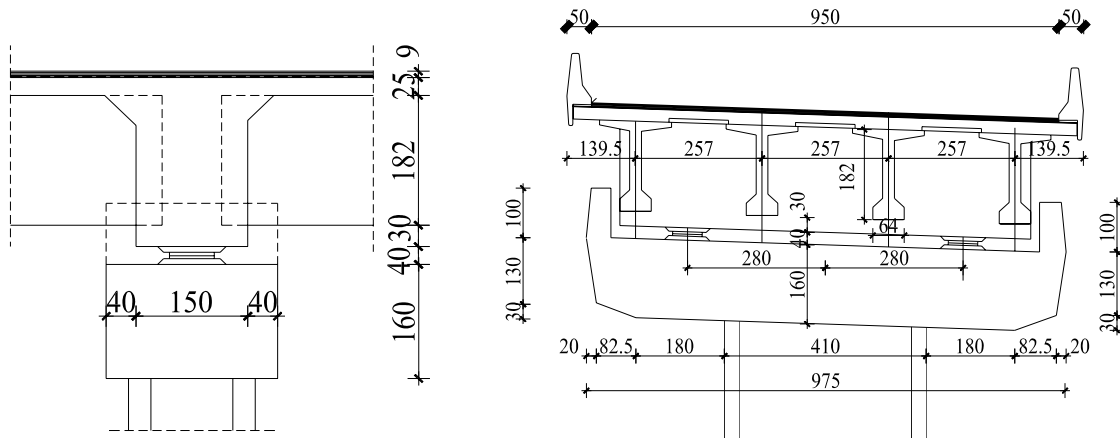


Figure 3: Continuity above pier – continuous static system

Big advantage of this static system is their durability. They have less “weak” points in sense of durability (less bearings, easier drainage etc.) less connections which can be damaged. Cross-girders are constructed in situ.

PRODUCTION OF PRECAST ELEMENTS

Structures of both of these structural systems constructed with precast girders demand huge production of precast girders regardless of static systems. At big construction projects such as there are several underway in Croatia, it is very difficult to organize girder production process which can meet construction site organizational requirements.

One of the biggest construction projects that require large number of precast girders or elements in general is definitely motorway construction. The construction site of motorway section is usually 15 or more kilometers long. At the moment there are several motorway sections under construction in Croatia at total length of 452 km. This year 150 km are to be open to traffic. Croatian construction industry, with help in organization and construction of American company “Bechtel”, is building these motorways. Total of more than 7500 precast girders and more than a million other precast elements (curbs, New Jersey elements, cornices etc.) are to be produced in a 4 year period. These numbers show what kind of precast element production is needed to meet construction site requirements.

There are two ways of organizing precast element production in this kind of construction. Concrete plants for production of precast elements can be located away from construction site or it can be located at construction site and be moved due to construction requirements.

Croatian construction companies in business in these parts for more than 60 years and with more than 50 years experience in precast element production, have their own concrete plants, located near companies headquarters. This kind of precast element production is better for continuous production for different construction sites and requires only one concrete plant with bigger production capacity. In these kind of concrete plant where production is continuous staff doing the works is highly qualified, production process is optimized, it can cover more than one construction site at the same time and precast element production can't be influenced by construction site delays. Organizing scheme of concrete plant for precast element production is shown on Figure 4.

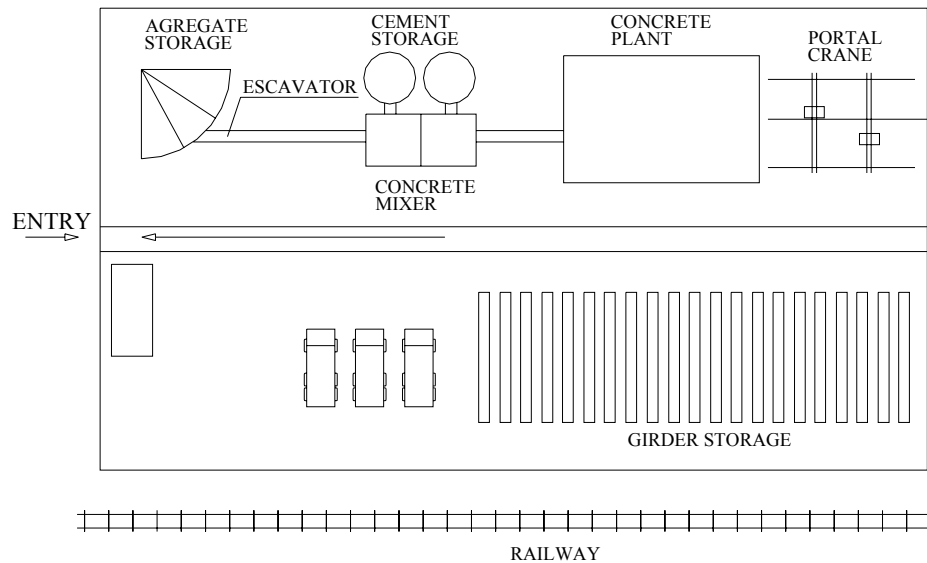


Figure 4: Organizational scheme of a concrete plant

Figure 4 shows organizational scheme for any concrete plant. Permanent concrete plants, which were mentioned before have more than one production line and they have larger storage areas. Problems with this kind of concrete plants are storage of produced precast elements and their transportation to construction site. These two facts are the limiting factors for precast elements production in such concrete plants. Usually these concrete plants are built near railways so that transportation of produced precast elements can be easier and cheaper. But if the construction site is not close to railway therefore there has to be organized transportation from railway line to construction site. These are factors that enlarge costs of production of precast elements away from construction site.

Precast element transportation specially transport of precast girders for motorway structures which dimensions are relatively big, on existing roads is complex process since it requires involvement of police and special traffic regulations during transport. The weight of precast girders is big (up to 200 ton) and their transport on existing roads, which were not designed for such loads, devastate roads and local population and their transportation is endangered. Such transport requires road repairs after transport of precast girders to construction site is finished.

Figure 5 shows transportation of precast girder on Caper motor trailer. Total weight of this girder is more than 200 tons, which means that each part of trailer has 100 tons loads. These are very big loads for existing road.



Figure 5: Girder transport on Capperi trailer

Precast element production plants that are organized for big construction project such as construction of motorways are, are located at construction site, at special areas organized for this purpose. They are organized in similar way as those dislocated to construction site, but usually are easier to move and remove after production is finished. Their work is not continuous and is connected to one particular construction site. Location of this kind of precast element production plants is connected to motorway sections. Contractors such as American company “Bechtel” is, which construct big motorway projects (more than 150 km long) usually have one or two production plants for production of precast girders on motorway sections. They are moved along the route of the motorway and their movement depends on construction needs. Their disadvantages are smaller production capacity and problem with storage space. Their big advantage is short transportation of precast elements to the construction site.

For construction of 3A2 section on Bosiljevo-Sveti Rok highway on route of Zagreb-Split highway additional grounds had to be purchased for girder storage as shown on Figure 6.



Figure 6: Girder storage at site

PRECAST ELEMENTS PLACING

After girders were produced they have to be placed on their place in structure. This is done on several ways and the most used are shown here.

On structures which level line is designed low above ground surface girders are placed with car cranes. This method of girder placing requires mostly horizontal grounds under car cranes and if it is not the case special plateau to insure safe grounds for car cranes are constructed. Girder placing with car cranes can be used also in cases where using any other method is not economically justified. This was the case on viaduct Dreznik, where two car cranes were used for placing of girders above Kupa River (Fig. 7).



Figure 7: Girder placing at Kupa River crossing - Viaduct Dreznik

On structures built on severe ground configuration and on those that have highly designed level line girders were placed with launcher (Fig.8). This is very slow method of girder placing since every time launcher has to go all the way back to the abutment to pick up another girder.



Figure 8: Girder launching

This problem emerges especially during construction of long viaducts (more than 500 m).

To overpass this problem after first several spans were placed, deck slab was concreted and when it had needed strength girders were transported over completed deck slab. Special calculations of deck slabs were conducted and needed reinforcement was added. Figure 8 shows launching of girders on viaduct Krajine on Zagreb – Split motorway.

Due to contractor's technology in some cases piercaps had to be designed in a way to ensure enough space for launcher supports (Fig.9) – they are wider than in the first version of design.

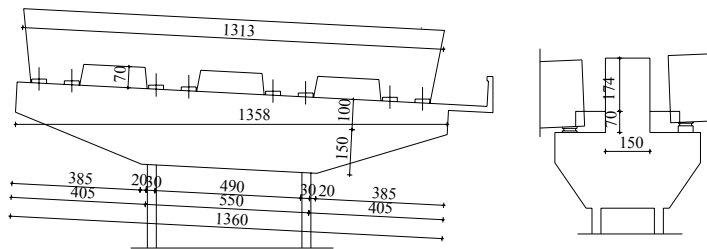


Figure 9: Piercaps with space for launcher supports

CONCLUSION

Precast element production especially production of precast prestressed girders is a complex process. It can be influenced with many outside factors and it represents very important procedure in construction of structures made of precast elements. Good organization of precast girder production can speed up construction a great deal. Both ways of production and transportation of precast elements were used during most recent construction of motorway sections in last several years. On each new section some improvements were made to optimize precast element production and their transport to the construction site.

REFERENCES

1. Tkalcic D., Ivkovic J., Sesar P., Krecak A.: Short Span Structures On Licki Osik – Sveti Rok Section Of The Bregana – Zagreb – Dubrovnik Motorway Route, *Proceedings of the Sixth International Conference on Short & Medium Span Bridge, Vancouver, BC Canada: Developments in Short & Medium Span Bridge Engineering – 2002, Vol.1*, July-August, 2002, pp. 491-498
2. Tkalcic D., Sesar P., Krecak A.: Construction Technology Of Bridges Designed By IGH Bridge Division, *Proceedings of the Symposium New Technologies in Croatian Construction, Brijuni Islands*, June 2003, Croatia, pp.143-150 (in Croatian)