

## **The Structural Behaviour of Composite Beams with Prefabricated Reinforced Concrete Plate (In Zone Positive Moment)**

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### **ABSTRACT**

The beam which is taken up in this study is composed of a prefabricated reinforced concrete plate in dimensions of 3000.800.100 mm and a steel profile (INP 120) under the beam. The steel reinforcement which should exist in the positive moment zone of the prefabricated reinforced concrete plate is replaced in while the plate has been prepared. Epoxy resin is used to provide the connection of the prefabricated concrete plate and the steel profile. The sliding and the lifting forces between the prefabricated reinforced concrete plate and the steel profile are reacted by the agglutination property of the epoxy resin.

The composite beams which are composed of reinforced concrete floor plate and steel beams or bridge floor and steel beams are more economical than the steel beams that carries reinforced concrete plate freely on its own because in a composite beam the tensile component of the force pair, which is due to bending, is carried by the steel profile and the compressive component that is also due to bending is carried by either reinforced plate or a of the reinforced concrete plate and steel profile cooperation system. So, the steel profile gets rid of carrying the compressive component of bending either completely or partially. In this way, the reinforced concrete plate carrying the dead load turns out to be a useful element which carries the compressive component, and in this cooperation, the lever arm of the force pair become greater, so a good economical factor is constituted by this situation.

The composite beams are always lighter than the reinforced concrete beams. In the composite beam, less steel is used than the reinforced concrete beam which has the same height. In the composite beams, a combination material called epoxy resin is used to provide the cooperation between the prefabricated reinforced concrete plate and the steel profile. During the cooperation between the concrete and the steel profile, the sliding and the lifting forces between the two materials are reacted by the help of the epoxy resin.

There are not more researches about this subject (Especially, about the composite beams which consist of the reinforced concrete plate and the steel profile combined by the epoxy resin in the positive moment zone). Generally in the studies with the epoxy resin, the cooperation of the steel plate and the reinforced concrete beam is researched.

The main purpose of our study is to research the bearing behavior of reinforced concrete beams and steel elements in the positive moment zone, and also to research how the cooperation by means of the steel profile and plates existing in the reinforced concrete beam

(Agglutinated with epoxy resin) is materialized (Sliding and separation of epoxy resin from the steel etc.)

The results which are obtained in this experimental study are in accordance with the results of the theoretical computations that have been done. This study is about the cooperation of the prefabricated reinforced concrete plate and the steel profile. The effect of the concrete quality variation on the bearing strength is researched, and certain suggestions are given.

In this study, the composite beam, which is taken, is composed of a prefabricated reinforced concrete plate in dimensions of 3000.800.100 mm and a steel profile. The reinforced concrete plate that forms the compressive headpiece of the composite beam will be connected with the steel profile later (Fig.1).

While the composite beam has been prepared, the various elements which provide the connection of the prefabricated reinforced concrete plate and the steel profile are located in the concrete during the production of the reinforced concrete plate. These elements that are located in the prefabricated reinforced concrete plate provide the connection of the reinforced concrete plate and the steel profile. The connection elements composed of U80 profile are used as the steel which provides the connection of the prefabricated reinforced concrete plate and the steel profile.

These connection elements are obtained by welding the UNP 80 profile to the steel plate in dimensions of 250.200.5 mm on its four sides and it is located in certain distances when the prefabricated reinforced concrete plate has been prepared by pouring concrete into the mold (Fig.2). The interconnection elements in the prefabricated reinforced concrete are combined to the steel profile by the help of the epoxy resin, and so the composite beam is achieved.

**Keywords:** Composite Beams Reinforced Concrete Plate, Steel Profile, Epoxy Resin and Structural Behavior.

## INTRODUCTION

The composite beams which are composed of reinforced concrete floor plate and steel beams or bridge floor and steel beams are more economical than the steel beams that carries reinforced concrete plate freely on its own. Because, in a composite beam the tensile component of the force pair which is due to bending is carried by the steel profile and the compressive component that is also due to bending is carried by either reinforced plate or a of the reinforced concrete plate and steel profile cooperation system. So, the steel profiles get rid of carrying the compressive component of bending either completely or partially. In this way, the reinforced concrete plate carrying the dead load turns out to be a useful element which carries the compressive component and in this cooperation, the lever arm of the force pair become greater, so a good economical factor is constituted by this situation.

The composite beams are always lighter than the reinforced concrete beams. In the composite beam, less steel is used than the reinforced concrete beams which have the same height.

In the composite beams, a combination material called epoxy resin is used to provide the cooperation between the prefabricated reinforced concrete plate and the steel profile.

During the cooperation between the concrete and the steel profile, the sliding and the lifting forced between the two materials are reacted by the help of the epoxy resin.

There are not more researches about this subject (Especially, about the composite beams which are consist of the reinforced concrete plate and the steel profile combined by the epoxy resin in the positive moment zone).

Generally in the studies with the epoxy resin, the cooperation of the steel plate and the reinforced concrete beam is researched.

The main purpose of our study is, researching the bearing behavior of reinforced concrete beams and steel elements in the positive moment zone, and also researching how the cooperation by means of the steel profile and plates existing in the reinforced concrete beam (Agglutinated with epoxy resin) is materialized (Sliding and separation of epoxy resin from the steel etc.)

About this subject, in the experimental studies which are carried out by R.N. Swamy and R. Jones Swamy (1987, 1989, 1995) [10, 11, 12], the bearing capacities and the bearing behavior of the reinforced concrete beams with steel elements agglutinated by the epoxy resin and how the sliding and the separation between the steel element and the reinforced concrete beam is materialized, are researched.

Besides, in the studies of Dr. T.M. Roberts and H. Haji - Kazemi (Roberts 1989) [7, 8], certain model researches are done theoretically to determine the distribution of the sliding and the normal strain throughout the coherence surface of the beams which are composed of the reinforced concrete plate and the steel elements agglutinated with the epoxy resin and equation are suggested for these kind of composite due to the results.

## **OBJECTIVE**

The objective of the study is to research the influence of the epoxy resin which provides the cooperation of the prefabricated reinforced concrete plate and the steel profile in the positive moment zone on the bearing behavior of the composite beam and also to find out how the additional equipment located in the prefabricated reinforced concrete plate and the steel profiles agglutinated with the epoxy resin affect the bearing behavior of the composite beam. Besides in this study, as a result of the deformation of the composite beam under loading, the epoxy resin's degree of precaution on the rising and sliding of the prefabricated reinforced concrete collaborating with the steel profile is researched. The quality of the reinforcement that is replaced in the reinforced concrete plate is BS-1 and that of the steel profile which forms the composite beams is St 37. As the results of the tensile tests, the quality of the steels which are used is determined exactly.

The results of this experimental study will be compared with that of the theoretical computations. In the subject which is about the cooperation of the prefabricated reinforced concrete plate and the steel profile, how the variation of interconnection element distances affect is researched and certain suggestions are done.

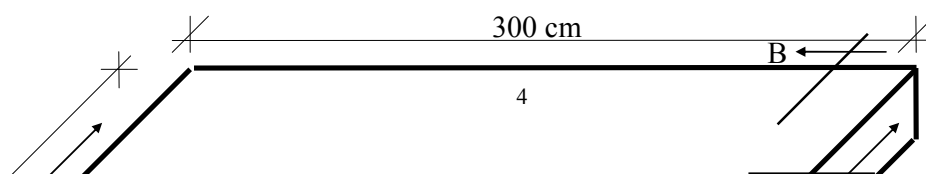
## **EXPERIMENTAL STUDY**

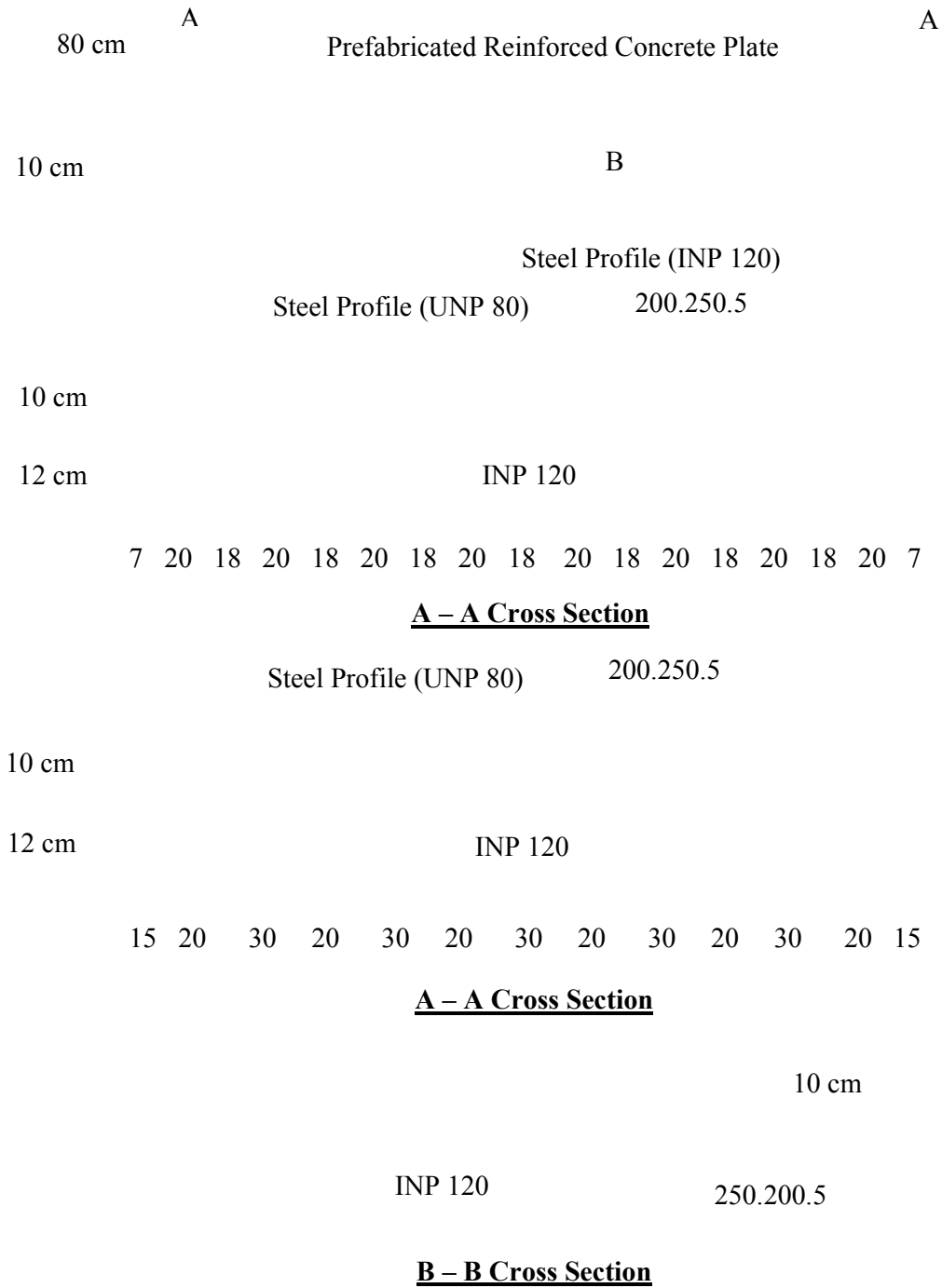
In this study, the composite beam which is taken is composed of a prefabricated reinforced concrete plate in dimensions of 3000.800.100 mm and a steel profile. The reinforced concrete plate that forms the compressive headpiece of the composite beam will be connected with the steel profile later (Fig.1).

While the composite beam has been prepared, the various elements which provide the connection of the prefabricated reinforced concrete plate and the steel profile are located in the concrete during the production of the reinforced concrete plate. These elements that are located in the prefabricated reinforced concrete plate provide the connection of the reinforced concrete plate and the steel profile. The connection elements composed of U80 profile are used as the steel which provides the connection of the prefabricated reinforced concrete plate and the steel profile.

These connection elements are obtained by welding the U80 profile to the steel plate in dimensions of 250.200.5 mm on its four sides and it is located in certain distances when the prefabricated reinforced concrete plate has been prepared by pouring concrete into the mold. The interconnection elements in the prefabricated reinforced concrete are combined to the steel profile by the help of the epoxy resin and so the composite beam is achieved.

When this composite beam is located on the experiment frame with joints and supports, a singular force is applied on the centre of the beam. The influence of the agglutination with the epoxy resin which occurs between the steel profile and the steel connection elements located in the prefabricated reinforced concrete plate and the degree of the epoxy resin's assistance (from the point of the connection elements' number and the epoxy resin) in the cooperation of the composite beam is researched. For this purpose, two different kinds of reinforced plates are prepared. Totally, 6 prefabricated reinforced concrete plates, two each which are 6 or 8 interconnected prefabricated reinforced concrete plates are prepared. The reinforced plate is connected with the steel profile by the help of the epoxy resin. As the result of the composite beam tests, the bearing capacities are given in Table 1 and the Load - Deformation diagrams are given in Figure 2 ~ 4.

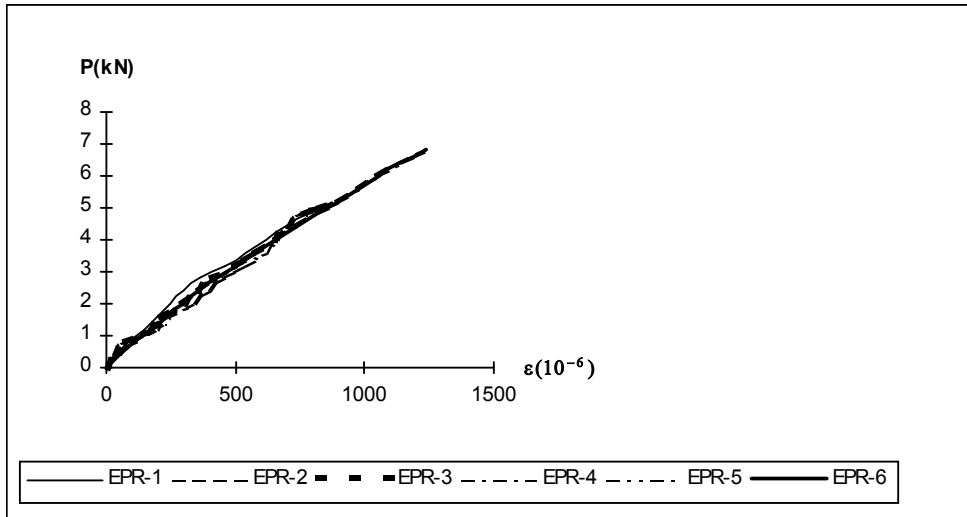




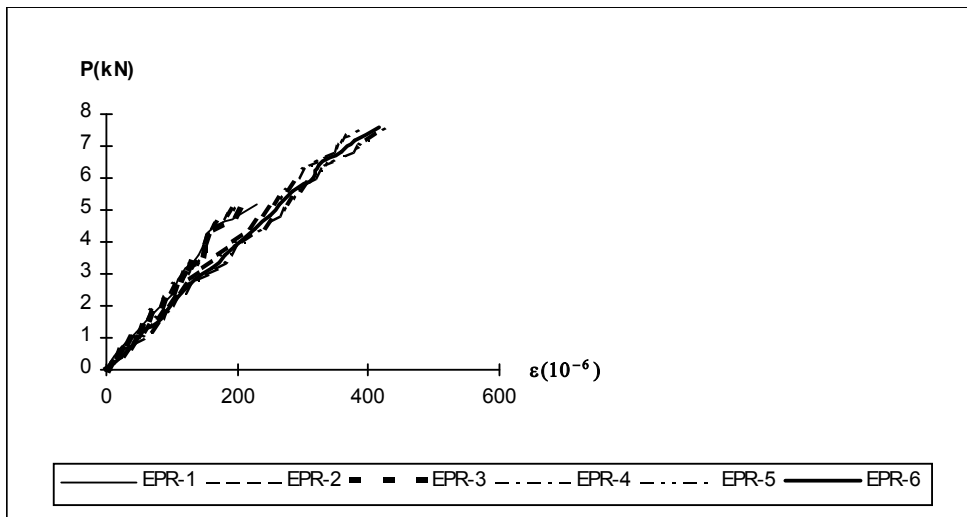
*Fig.1.* Details of Composite Beams

*Table 1.* The Values of the Beam Cross Section and the Bearing Capacities

Sample Number	Concrete Dimension (mm)	Steel Profile Number	Interconnect Point	The Rate of The Concrete	Bearing Load (kN)
<b>EPR-1</b>	3000.800.100	INP 120	6	C 30	5,5
<b>EPR-2</b>	3000.800.100	INP 120	6	C 30	5,6
<b>EPR-3</b>	3000.800.100	INP 120	6	C 30	5,8
<b>EPR-4</b>	3000.800.100	INP 120	8	C 30	7,7
<b>EPR-5</b>	3000.800.100	INP 120	8	C 30	7,9
<b>EPR-6</b>	3000.800.100	INP 120	8	C 30	8,0



*Fig.2. Load - Deformation Diagram (Steel)*



*Fig.3. Load - Deformation Diagram (Concrete)*

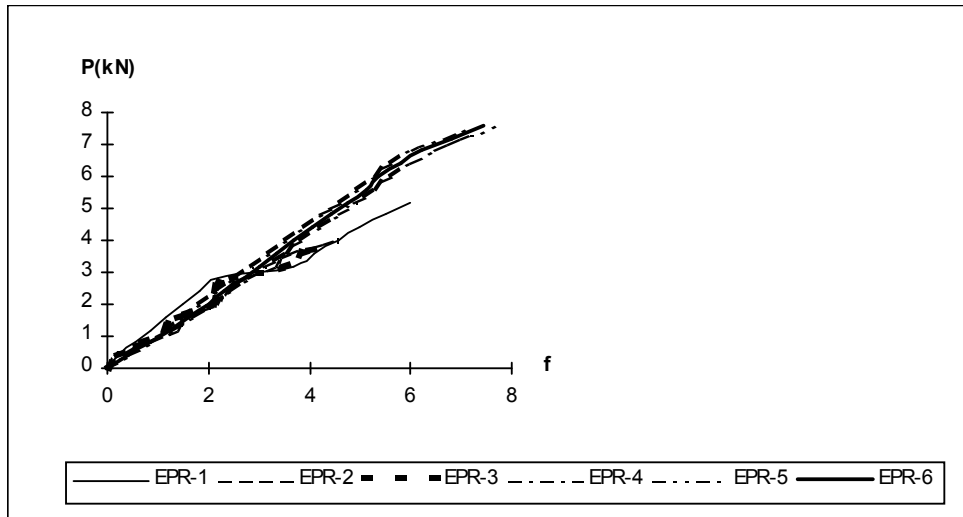


Fig.4. Load - Displacement Diagram (Centre of the Beam)

## RESULTS AND DISCUSSIONS

In the first stage of this work the adhesive between composite concrete beam and the steel profile (INP 120) were applied at six points. The deflection and loading capacity of this system were obtained. In the second stage the numbers of adhesion points were risen to eight constraint points. All the test results of the first and second stages are shown in Table 1.

The experimental results are summarized in:

- The adhesion bonding is between the steel plate of the composite concrete and the steel profile and all loads are carried out by the epoxy resin. In examining the strength of the adhesive bond, our preliminary studies showed that in case of adhesion between the concrete and steel profile, the tensile strength of the concrete was nearly zero. This resulted in shearing of the profile from the concrete which resulted to weak joints and failure. Therefore to reach a sound construction the adhesion should be between the steel plates of the composite concrete and steel profile. The bonding strength of the epoxy for steel to steel case is much higher than that of concrete to steel.
- The results of the first and second stages tests showed that: For 6 fixing points construction system the average loading capacity is 5,63 kN and the bonding area is about 696 cm<sup>2</sup>. For 8 fixing points system the average loading capacity is 7,86 kN and bonding area is 928 cm<sup>2</sup>. It is well known fact that the longer the adhesion area the stronger is the bonded joint. Therefore using 8 fixing points the sounder is the construction. The longer the number the shorter are the distance between the joints with minimize the deflection. Examining the influence of the distance between the constraint points is planned as a further work in this field.
- The bonding strength between steel and steel is 470 % longer than that of concrete to steel.

The most economical and sound composite prefabricated to profile steel joints are obtained by using adhesive epoxy between steel plates of the composite and the steel beam.

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