Comparison of the Strength of Normal Sections of Rubber Concrete Rectangular and T-beams

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Comparison of the Strength of Normal Sections of Rubber Concrete Rectangular and T-beams

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Abstract. Polymer concretes permit to solve the problems associated with the influence of aggressive environment of various natures. Aggressive media, penetrating through the cracks in the body of the structure, in addition to corrosion of concrete, lead to corrosion of the reinforcement and, consequently, the load-bearing capacity of the element significantly reduced. The different types of polymer concrete are furan, epoxy, polyester and others. At the Department of Building Constructions, Bases and Foundations of the Voronezh State Technical University (VSTU), rubber concrete (rubcon) was developed, which is one of the types of polymer concrete based on liquid rubbers. This liquid rubber is produced at the Voronezh Synthetic Rubber Plant (SK-2). Rubcon has favorable physico-mechanical properties, high strength and high chemical resistance (almost universal). Thus, rubcon allows solving the problems of corrosion of various structures functioning under the influence of aggressive media.

1. Introduction
The use of materials that have increased strength, corrosion resistance, durability, and as well facilitate the reduction of overhaul periods, is one of the current trends in the development of the construction industry.

In industrial plants, where structures are exposed to aggressive media, there is a need to use new high-strength and corrosion-resistant materials. Polymer concrete plays a big role in solving the problems associated with corrosion of the reinforcement and increase in the load-bearing capacity of the structures as a whole. The different types of polymer concrete in construction practice are furan, epoxy, polyester e.t.c.

Diene oligomers belonging to the class of liquid rubbers, as a type of available polymers, permit solving the problems of protection of structures from corrosion.

Rubber concrete is a special type of polymer concrete, created based on liquid rubbers, which solves problems associated with protection against corrosion of various products and structures operating under the influence of aggressive media, by possessing favorable physico-mechanical characteristics and high chemical stability.

Borisov Yu.M. [1, 2, 3], Nguyen P.D. [1,2,4], Panfilov D.V. [3,5], Perekalskiy O.E. [6], Pinaev S.A. [7, 9,10], Polikutin A.E. [1,2,8,9,11], Potapov Yu.B. [10,11,12,14], Chmykhov V.A. [13], Figovskiy O.L. [14] and others [15], described the properties of rubber concrete, and they also verified the effectiveness of using this material and structures based on it. The composition of rubber concrete and its properties are presented in tables 1, 2, and 3.
Table 1. Component composition of rubber concrete

| Name of components                                      | Content of components, mass, (%) |
|---------------------------------------------------------|----------------------------------|
| Cis-polybutadiene low-molecular rubber SKDN-N            | 8.0                              |
| Industrial sulphur                                      | 4.0                              |
| Tiuram- D                                               | 0.4                              |
| Zinc oxide                                              | 1.6                              |
| Calcium oxide                                           | 0.5                              |
| Fly ash                                                 | 7.0                              |
| Quartz sand                                             | 24.0                             |
| Crushed stone                                           | 54.5                             |

Table 2. Rubber concrete chemical resistance coefficients

| Kind of aggressive media         | Coefficients of chemical resistance |
|---------------------------------|-------------------------------------|
|                                 | After 1 year of exposure | Projected after 10 years |
| 20 % solution of sulphuric acid | 0.95                          | 0.95                      |
| 3 % nitric acid solution        | 0.8                           | 0.7                       |
| 10 % citric acid solution       | 0.9                           | 0.8                       |
| 20 % solution of caustic soda   | 0.95                          | 0.95                      |
| 10 % solution of caustic potassium | 0.8             | 0.65                      |
| Saturated sodium chloride diesel| 0.9                           | 0.8                       |
| Combustible diesel              | 0.95                          | 0.95                      |
| Water                           | 1                             | 0.99                      |

Table 3. Physico-mechanical properties of rubber concrete

| Properties                             | Indices for rubber concrete |
|----------------------------------------|-----------------------------|
| Compressive strength, (MPa)            | 70…100                      |
| Tensile strength, (MPa)                | 10…20                       |
| Modulus of elasticity, (MPa)           | (1,5…3,0)×10⁴               |
| Coefficient of the duration of compression | 0.72…0.76                 |
| Poisson’s ratio                        | 0.2…0.3                     |
| Heat resistance, (°C)                  | 100…110                     |
| Frost resistance, number of cycles of freezing-thawing, not less than | 500 |
| Abradability, (g/cm²)                  | 0.25…0.79                   |
| Water absorption, (%)                  | 0.05                         |
| Shrinkage, (mm/m)                      |                             |

The purpose of this work is to compare the strength of normal sections of rubber concrete rectangular and T-beams with the same dimensions and reinforcement.

2. Experimental researches on rubber concrete beams of T-section and rectangular section.

To achieve this goal, three sample series of rubber concrete beams of T-section and three sample series of rubber concrete beams of rectangular cross-section were produced in the laboratory. All the beams were tested for transverse bending by two equally concentrated symmetrical point loads.

For reinforcement, a rebar of class A500C with diameters of 10 mm, 12 mm and 2x12 mm was used (with the following percentages of longitudinal reinforcement for the T-section 0.73%, 1.05%, 2.1% and 1.26%, 1.80%, 3.59% for the rectangular cross-section). The beam-loading diagram is shown in figure 1.
Figure 1. Beam loading diagram

The T-beam before the experiment is shown in figure 2, the rectangular beam before the experiment is shown in figure 3. The experiment on the beams took place in the Center of Collective Use (CCU) of the Voronezh State Technical University (VSTU).

Figure 2. T-Beam before the experiment

Figure 3. Beam of rectangular section before the experiment
Figure 4 shows a T-beam with a normal crack after the experiment. Figure 5 equally shows a rectangular beam with a normal crack after the experiment.

![Figure 4. T-beam after the experiment](image1)

![Figure 5. Beam of rectangular section after the experiment](image2)

Table 4 shows the parameters of rubber concrete flexural members of rectangular and T-sections.

| Research on the effect of the percentage of longitudinal reinforcement on the strength of normal sections |
|--------------------------------------------------------------------------------------------------|
| Length of rectangular and T-beams, (mm) | 1400 |
| T-beam web width, (mm) | 60 |
| Beam width of rectangular section, (mm) | 60 |
| T-beam flange thickness, (mm) | 25 |
| T-beam flange width, (mm) | 240 |
| Height of rectangular and T-beams, (mm) | 120 |
| Quantity and diameter of longitudinal reinforcement bars of rectangular and T-beams, (mm) | 1 Ø 10; 1 Ø 12; 2 Ø 12 |
| Percentage of longitudinal reinforcement of T-beam, (%) | 0.73; 1.05; 2.1 |
| Percentage of longitudinal reinforcement of rectangular beam, (%) | 1.26; 1.80; 3.59 |
As a result of conducted experiments on beams of rectangular and T-sections, the relationship between the fracture moment and percentage of longitudinal reinforcement was obtained (see figure 6). For the fracture bending moment, the moment at which the stresses on the rebar reached the yield point was taken. With further loading, the deformations of the beams intensively increase at a practically constant value of the load.

![Figure 6. The relationship between the fracture moment and percentage of longitudinal reinforcement (µ) of beams of rectangular and T-sections](image)

3. Conclusion

Analysis of the relationship presented in figure 6 shows that the increase in the strength of the normal cross sections of reinforced rubber concrete beams of rectangular and T-sections with an increase in the percentage of longitudinal reinforcement occurs according to a linear relationship. In this case, the fracture bending moment of T-beams increases more intensively in comparison to rectangular beams, which may indicate a greater effect of the chosen variable parameter (percentage of longitudinal reinforcement) on the strength of the normal section of the T-beams. In addition, it should be noted that the strength of normal sections of the rubber concrete T-beams is higher than that of the rectangular beams with the same content of longitudinal reinforcement (due to the greater content of rubber concrete in the compressed zone).

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