EARTHQUAKE-RESISTANT REINFORCED CONCRETE STRUCTURES

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SUMMARY

Self-regulation has allowed full utilization of the properties of steel and concrete. In this case the influence of an earthquake is compensated by the value of the prestress force. The results of testing analysis of self-regulating structures have proved that their carrying capacity can be one and a half time higher than that of traditional structures

INTRODUCTION

One of the principles for designing reinforced concrete is maximize the use of both the concrete and steel strength [1]. While there are distinct advantages of joint work of the two materials there are also shortcomings. Among them are their different strain abilities under loading. Under stretching concrete loses its integrity under strains 400-500 times less than the reinforcement within it. Hence we are forced to design structures with cracks in the concrete and also employ prestressing of steel. This problem may be solved to a considerable extent by developing reinforced concrete structures with self-regulating steel stress [2] and corresponding concrete compression [3].

2. METHOD OF SELF-REGULATION

The system of auto-regulation includes reception, control and performance blocks. Full auto-regulation requires high speed work of all the system's links, its reliability, continuous power supply and service. A more limited, but reliable one-link system of self-regulation was developed that includes only a performance block. Self-regulating of stress-strain state of the concrete structure can be done according to the chart shown in Fig. 1. The singularity of the developed system is that it does not need external power for its work. As a result, self-regulating works at all stages of loading and unloading the structure. The stress-strain state of the structure is regulated. The structure works similar to the most economical natural mechanism – the body – where steel is associated with muscles which automatically strain under loading and relax after its removal. It's quite obvious that there is no need to constantly have steel "muscles" kept highly stressed to carry maximum loads that may probably never happen. This only leads to the fatigue of the "muscles" – steel and the "body" – concrete, and that may decrease service properties of the structure.

3. THEORETICAL AND EXPERIMENTAL ANALYSIS

High strength and durability are characteristic of reinforced concrete structures working with their full cross-section without cracks. Most often, cracks appear in the tensile zone of concrete. Therefore, the value of the

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compressive force should be such, that the neutral axis of the structure is displaced from the gravity center to the tensile zone, so that there is no cracking in the structure and concrete is working with its full section. That is, tensile strains in such a structure must not exceed the value of the strains corresponding to the limits of concrete strength: $\varepsilon < \varepsilon_{bt}$.

The values of moment ***M*** and force of compression ***N*** in the section of the structure are determined from the equilibrium equations, developed by the author. Here ***a*** is the modulus of resilience. For the stressed state it is defined as the corresponding area shown in Fig. 2. According to numerous experimental data on reinforced concrete bending elements it is known that their failure is always accompanied by the fracture of concrete in the compressed section zone. That's why, for the given elements, it is possible to accept the failure condition: $a \leq [a]$. Ultimate values of modulus of resilience ***[a]*** for the concrete are presented in Fig. 3. If the prestressing force ***N*** is along the neutral axis, then we have minimum function of work. Thus, the force of compression applied along the neutral line performs the least work in the structure, which leads to its minimum overloading.

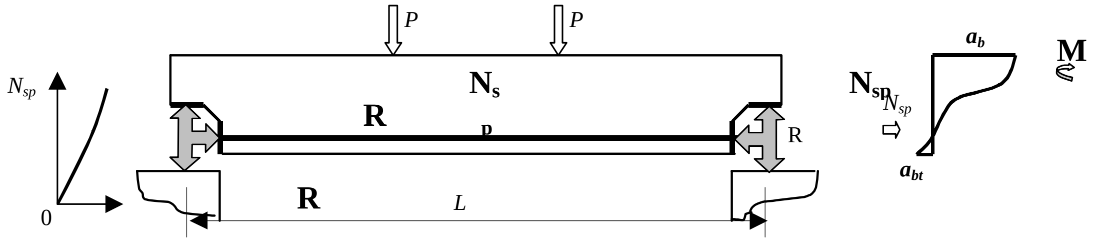

Fig. 1 Chart showing self-regulation of beam work

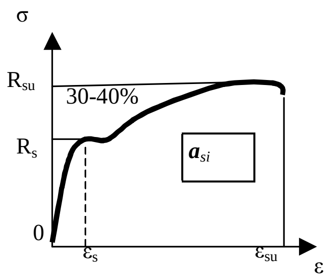

Fig. 2 Typical stress-strain curves for steel

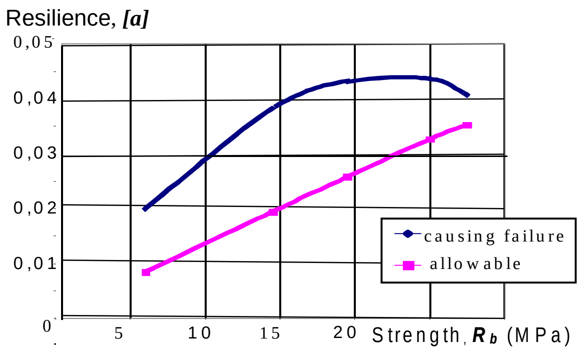

Fig. 3 Curvatures of ultimate values of resilience

Let's consider a beam with self-regulating steel stress. The beam stress state is regulated by the compression value ***N***. A variant of a cross section equilibrium without cracks is possible, (see Fig.1). In self-regulated beams the value of compression does not directly depend on strains. Here we have an opportunity to increase the efficiency of using strength properties of usual reinforcement steel by 30-40 per cent (Fig. 2). As it follows from the tests, it is possible to considerably raise beam strength due to self-regulating the force of compression. The most effective use of strength properties of reinforcement steel, is where the tensile zone of concrete cross section is available. Under the tested condition, self-regulation permitted the beam strength to increase by a half compared to the traditional beam, and it also prevented cracking.

4. CONCLUSIONS

The force of prestressing applied along the neutral axis imparts to the structure minimum strain energy, and doesn't overload the structure. The value of prestress force imparted to the structure is such that its neutral axis is displaced from the gravity center to the tensile zone so that there is no cracking in the concrete and the structure is working with its full cross-section. The full use of both concrete and steel strength can be provided when we have separate deformations of concrete and reinforcement under their joint force interaction. The value of optimum structure prestress varies depending on the influence of an earthquake. It is not provided under joint deformations of concrete and reinforcement, and so it should be regulated. Stress self-regulation of reinforced concrete structures ensures the application of the above given principles.

References

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