Taking into account the decrease in concrete strength in reinforced concrete buildings during long-term operation when designing reconstruction and reinforcement works

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Abstract: The reasons for the decrease in the strength of concrete in reinforced concrete building structures during long-term operation are considered. The results of the study were taken into account in the VII GTU.The building (which was built in the 1960s) When developing the reconstruction and strengthening project for the structures.

Key words: Concrete strength, service life, actual strength, climatic conditions, design, reinforcement, beam.

Introduction

Three types of normative exploitation periods of buildings and structures are distinguished:

1. **Design period of exploitation.** This is the period that designers set when creating an object, based on design solutions, properties of building materials and expected operating conditionsThe validity period is:
   - *For residential, public and industrial buildings - not less than 50 years.*
   - For buildings with monolithic walls and floors l – more than 100 years.
2. **Actual operating time.** It depends on real operating conditions. For example, exposure to aggressive environments, frequent and sharp changes in temperature and humidity, improper maintenance of structures can significantly reduce the estimated service life.
3. **Remaining service life**. It is determined based on the results of a technical inspection of the building and determines the service life without major repairs or reconstruction. [1] .

The aim of the article is to analyze the change in the strength of concrete in buildings constructed from monolithic reinforced concrete, which have been in operation for a long time, and to use its results in the reconstruction of buildings.

It is known that the physical and mechanical properties of concrete, including strength, change over time. After pouring the structure, the increase in concrete strength under appropriate conditions occurs intensively in the initial period and then slows down.

Увеличение прочности бетона с течением времени можно приблизительно определить по логарифмической зависимости [2]:

$$R_n = R_{28} \frac{\lg n}{\lg 28}$$

Where:: R_n და R_{28} - concrete strength at the age of n and 28 days respectively, MPa;

n- Age of concrete, day and night

Table 1 shows average data on the increase in strength of Portland cement concrete over time.

Table 1. Increase in the strength of concrete made with Portland cement over time.

Concrete ages day and night.	Relative compressive strength R_{28}=1	Age of concrete in years	Relative compressive strength R_{28}=1
7	0,6-0,7	1	1,75
28	1,0	2	2,0
90	1,25	4-5	2,25
180	1,5		

During operation, over time, the actual strength of concrete will be significantly lower than the standard. Its strength (and therefore service life) depends on the operating conditionsThe main factors affecting the durability of concrete are: The main factors affecting the durability of concrete are:

• Chemical impact;
• Impact of mechanical loads;
• Quality of preparation and laying of concrete

mix. Failure to comply with technological standards may lead to the formation of defects that reduce the durability of the material;

• Human factor. Insufficient knowledge, inexperience and carelessness may lead to errors at various stages of construction.

In the case of long-term operation of buildings and structures, when the strength of concrete is significantly reduced due to the impact of the above-mentioned negative factors, which creates a threat to the further operation of the building (or its individual structural element), there is a need for reconstruction-reinforcement of the said structural elements (or the building as a whole). If the cost of reconstruction is significant, there is a need to dismantle the structure (or the entire building) and build a new one.

The above considerations were taken into account by the authors of the article when planning the work to strengthen and reconstruct the VII building of the Tbilisi State Technical University, built in he 1960s (see photo 1).

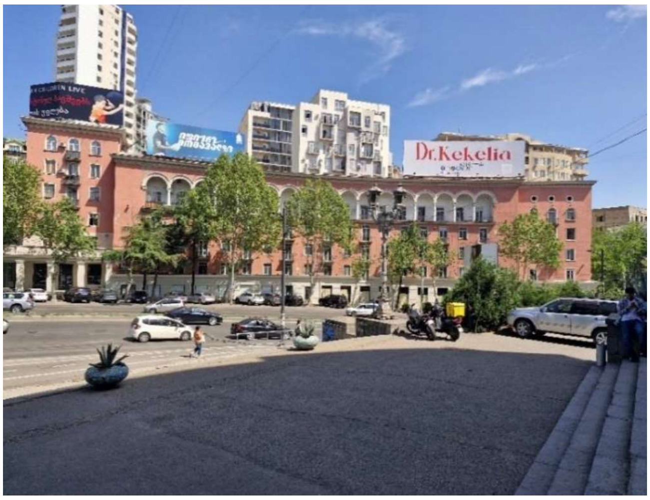


photo 1

Main Part

The VII building of the Tbilisi State Technical University is a 5-storey building with reinforced concrete longitudinal and transverse load-bearing walls and wooden interfloor ceilings, the load-bearing structure of which is monolithic reinforced concrete beams located across the building (see Fig. 1-4).

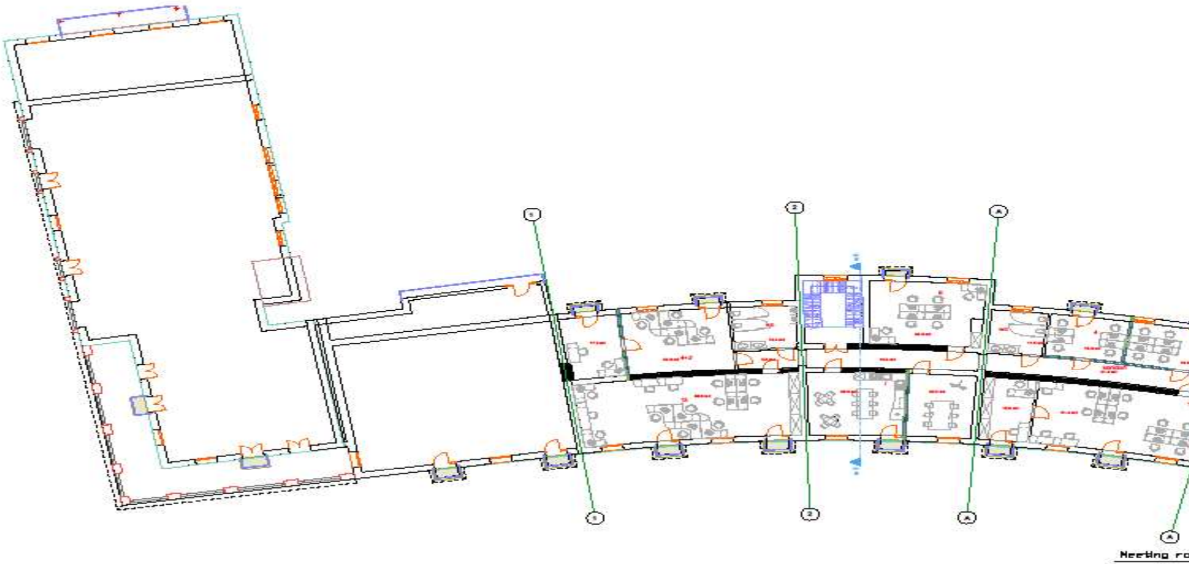


Fig. 1 Floor plan of the third floor

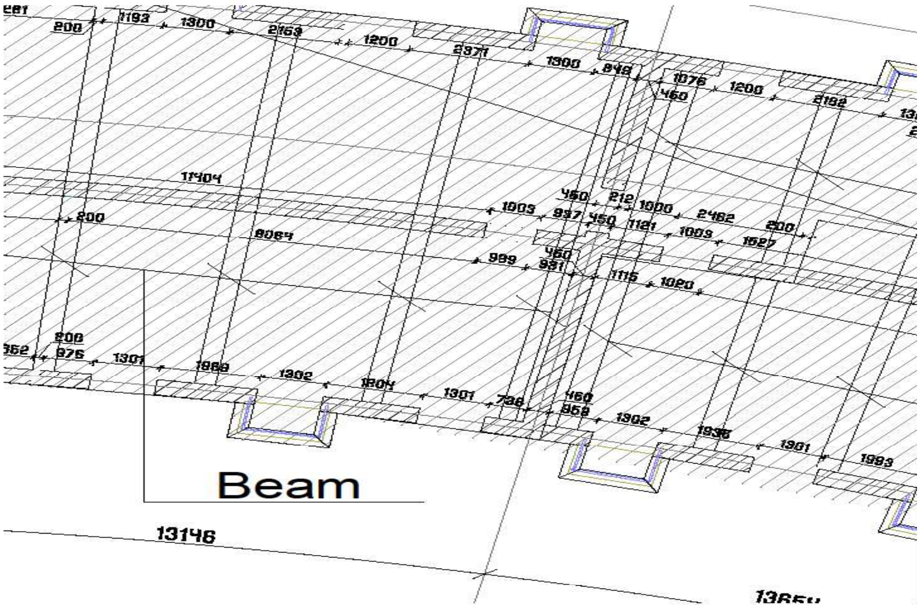


Fig. 2 Fragment of the plan showing the ridges

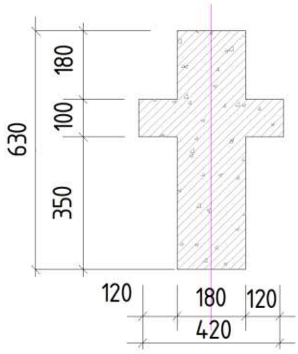


Fig. 3 beam section

Wooden floor installation scheme

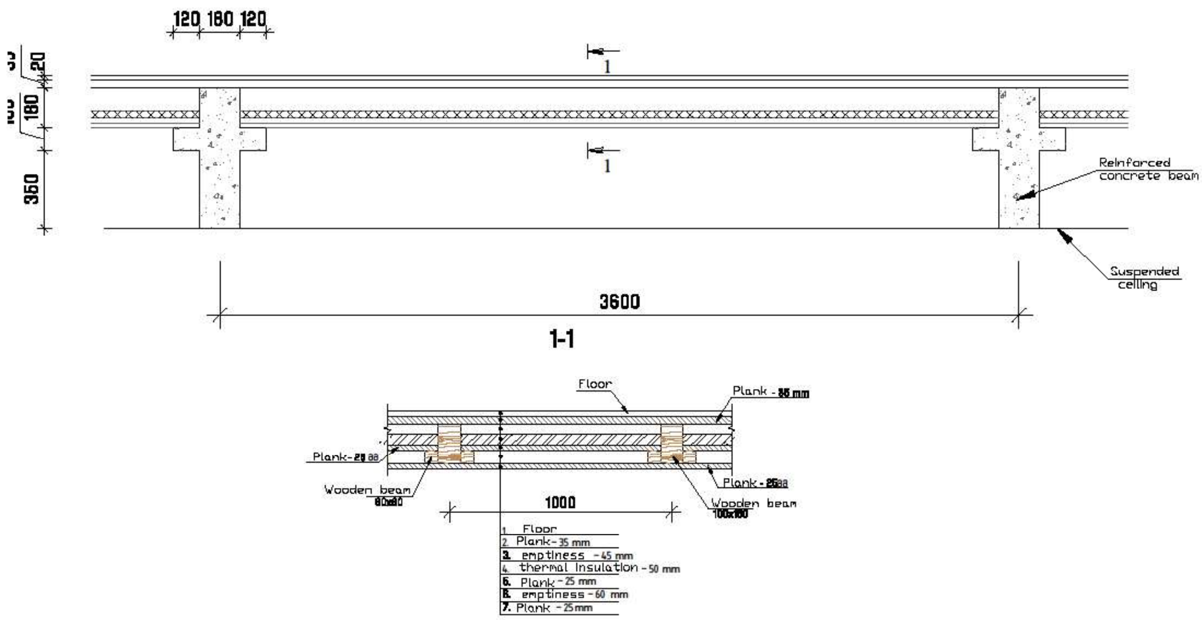


Fig. 4 Scheme of installation of new floor

Work on strengthening and restoring the building is expected to be carried out in accordance with the design project we have developed [3].

Due to the long-term operation of the building (about 70 years) as a result of the impact of the negative factors described in the introduction, the average strength of the concrete of its load-bearing walls (tuff rubble was used as a concrete filler) decreased to approximately 70 kg/cm2 (class B10), while the average strength of the concrete of the beams of the interfloor ceiling is 240 kg/cm2 (class B15).

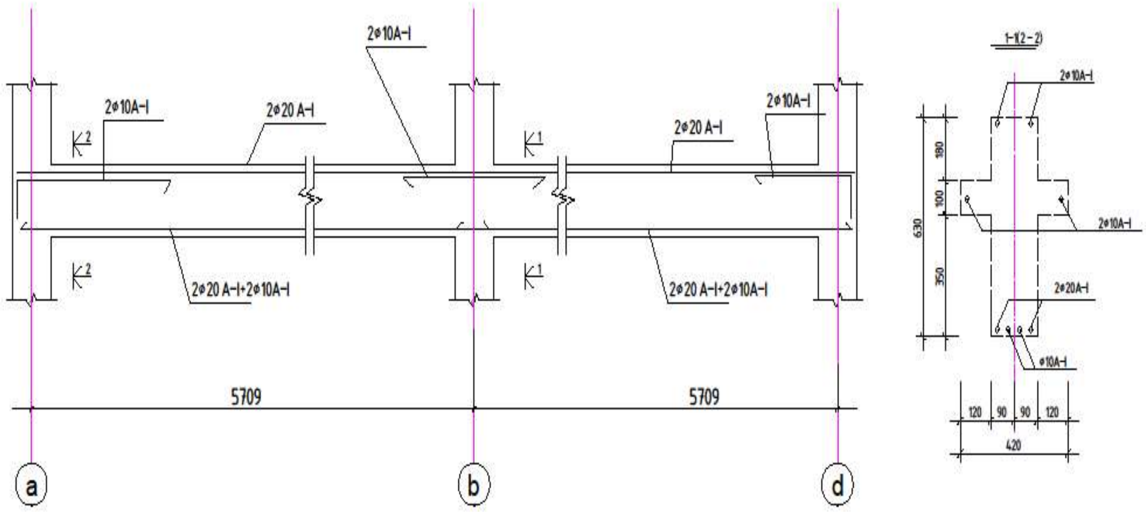


Fig. 5 Reinforcement of a two-span beam

The building has 2 types of beams: 2-span and 3-span. They are continuous beams

Note: Before starting work on strengthening the beams, it is obvious that the heavy wooden interfloor floors resting on them (which are damaged) must be dismantled, and after strengthening the beams, it is necessary to install light wooden interfloor floors.

The beams are reinforced with smooth reinforcement (due to the absence of periodic section reinforcement at that time). The reinforcement of the beams is shown in Figures 5 and 6

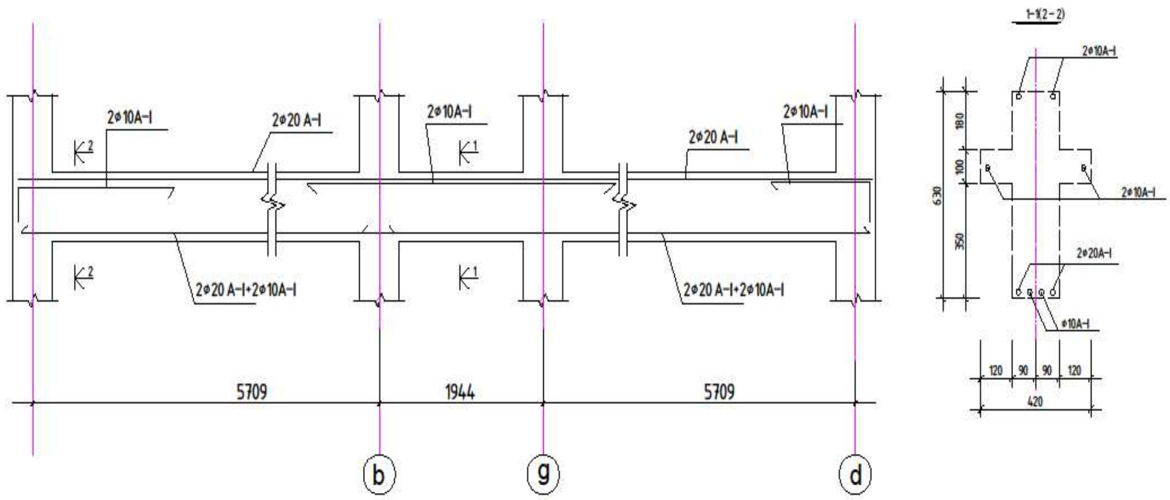


Fig. 6 Reinforcement of a three-span crossbar

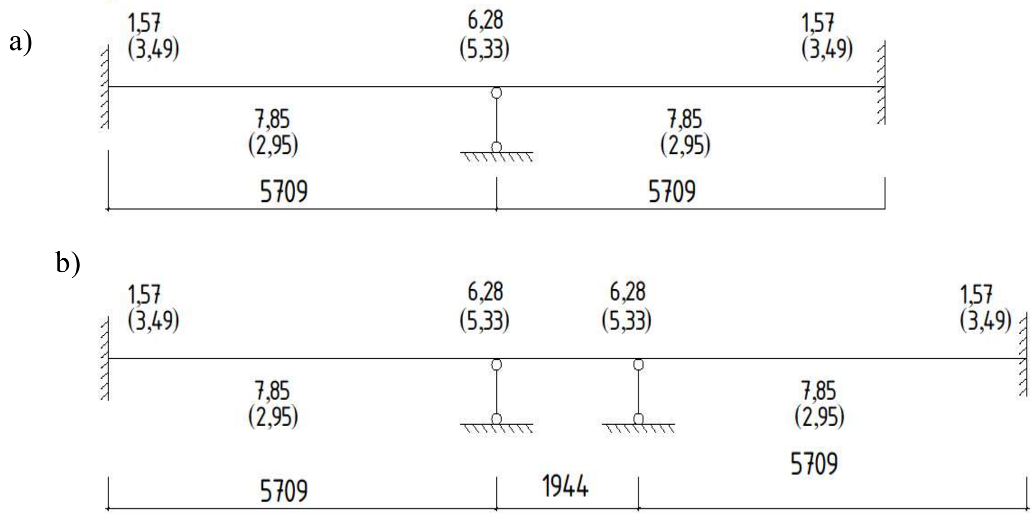


Fig. 7 shows a comparison of the required reinforcement of the beam cross-sections obtained by calculation with the existing reinforcement.

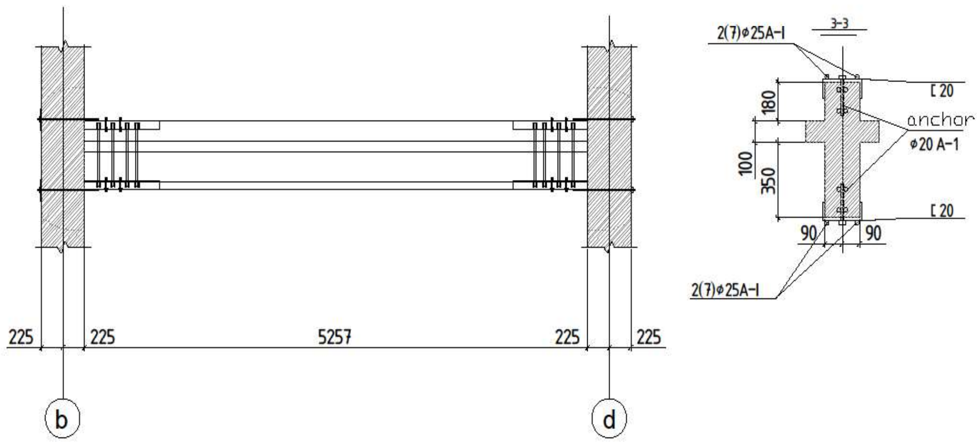
As a result of the computer spatial calculation of the building (obviously, taking into account the actual strength of the concrete of its walls and beams), the area of the obtained reinforcement (A500c) of the beams and its comparison with the existing one are shown in Fig. 7. a) Two-span beam; b) Three-span beam Note: The numbers without brackets reflect the existing reinforcement area of the beam sections, and those in brackets reflect the required area obtained as a result of the calculation.

It is evident from Figure 7 that the existing reinforcement of the beams is insufficient. (Moreover, it is also important to consider that in the future the strength of concrete will decrease even more). At the same time, the reinforcement in the beams corresponds to class A-I, while the required reinforcement obtained by calculation corresponds to class A 500.

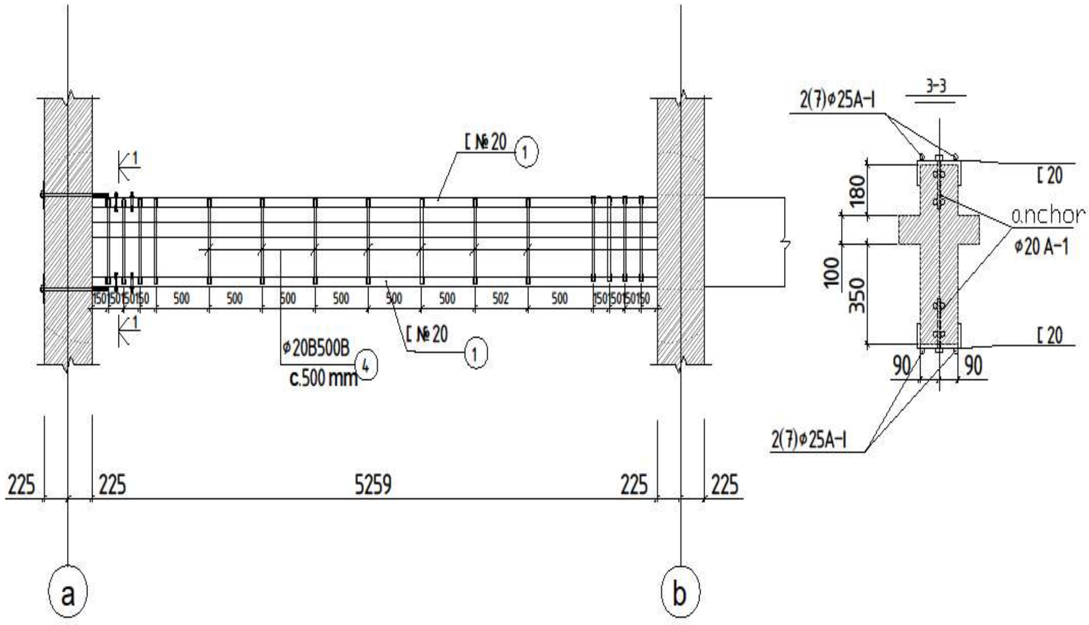
Because increasing the area of reinforcement of beams (both on supports and in the span) is impossible, and their dismantling and installation of new structures is unprofitable - for two reasons:

As a comparison of the actual and calculated reinforcement shows, reinforcement on the edge supports is usually insufficient. We will have two design solutions for reinforcing the beams:

1. Large financial costs are required;
2. The load on the lower part of the roof will increase due to the breakage of the rafter material. For the reasons stated above, it was decided to strengthen them with steel profiles.



Rice. 8. Reinforcement of beams in the support zone



Rice. 9 Reinforcement of beams along the entire length of the material

As a comparison of the actual and calculated reinforcement shows, reinforcement on the edge supports is usually insufficient. We will have two design solutions for reinforcing the beams:

1. Reinforcement of all beams of all floors in the support zone (except for the meeting room, where the useful load will be high);
2. Reinforcement of beams along the entire length (in the meeting room).

For design solutions for reinforcing beams, see Figures 8 and 9.

Conclusions

Upon expiration of the standard service life of buildings and structures, it is necessary to conduct an inspection of their technical condition, including spatial computer calculations taking into account the actual, changed (deteriorated) properties of materials. Based on the results obtained, a decision should be made:

• When the entire building is in a state of disrepair, it is obvious that it should be demolished and a new one built;

• If it is not the entire building, but its individual structural elements, that are in a state of emergency, they need to be reinforced in such a way that the safe operating life of the building (i.e. the remaining operating life) is increased for a considerable period of time.

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