

RESEARCH ARTICLE | MAY 31 2023

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AIP Conference Proceedings 2684, 030039 (2023)

<https://doi.org/10.1063/5.0120020>



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Characteristic Damages of Reinforced Concrete Structures of the Covering Exposed to Moisture

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Abstract. In the article the authors analyze the effects of reinforced concrete structures of the coating during operation, depending on the type of coating structure, roof composition, temperature and humidity. In addition, a fairly detailed list of plate defects that may occur during their manufacture or installation was made. Temperature-humidity influences on reinforced concrete structures of a covering can be only from influence of moisture during infringement of a temperature-humidity mode of a design. The reasons for the violation of the temperature-humidity regime are insufficient thickness of the insulation on the enclosing structures, violation of the buildings ventilation system, air conditioning and aeration of the attic space. This leads to condensation of moisture on the surface of reinforced concrete structures, it freezing and the formation of mold, which, in turn, leads to corrosion in concrete and reinforcement. Characteristic damages of reinforced concrete constructions of a covering on the basis of experience of inspection of buildings and constructions for the last 5 years are resulted and measures for ensuring their further safe operation.

INTRODUCTION

The operation of reinforced concrete ribbed slabs of a covering in industrial buildings of 60-80 years of the last century of construction has characteristic features that can be generalized and standardized methods of reinforcement can be developed. Typically, these are ribbed panels 6×1.5 (1.2) m with a height of the longitudinal rib 300 (350) mm and transverse ribs 80 (100) mm high and a reinforced mesh shelf 30 (40) mm thick. The composition of the roof may vary depending on the type of construction of the coating. In houses with a combined roof or in houses with a warm attic, a layer of insulation (usually expanded clay) 150-200 mm thick, a leveling cement-sand screed 20-40 mm thick and a roofing material were laid on the floor slabs. In houses with a cold attic, a leveling cement-sand screed 20-40 mm thick and a roofing material roof were installed on the ribbed slabs. Depending on the temperature-humidity regime and operating conditions, reinforced concrete structures of the coating are damaged. The study of the influence of temperature and humidity on the enclosing structures of buildings, the authors conducted in [2] for a tent roof and in [3] for wall constructions of buildings. The general analysis of the influence of moisture on the enclosing structures of the building (brick, reinforced concrete and wooden structures) was carried out in [1]. The authors dealt with the issues of inspection, repair, reconstruction and thermal modernization of roofs of buildings in [4, 5, 6]. Operational influences on reinforced concrete structures of a covering lead to formation of damages of designs which bearing capacity needs to be checked by calculations [7, 8, 9, 11, 12, 13], and, if necessary, perform reinforcement of structures [11, 14]. Therefore, the analysis of non-design effects of reinforced concrete structures of the coating during operation, the selection of characteristic damage to reinforced concrete structures is an urgent task.

NON-DESIGN EFFECTS ON REINFORCED CONCRETE STRUCTURES OF THE COATING DURING THEIR OPERATION

Reinforced concrete structures of the coating during operation are damaged due to manufacturing defects, installation defects and operational influences. Defects in the manufacture of reinforced concrete structures, such as the small thickness of the protective layer of concrete, lead to accelerated damage from operational influences. Mounting defects, such as insufficient length of the support platform or unwelded embedded parts at three points, can lead to critical damage to reinforced concrete pavement structures and loss of load-bearing capacity of the structure. The lack of a plane of the four points of support of the coating plate is also a mounting defect, which leads to twisting of the structure and cracking.

Operational influences on reinforced concrete structures of a covering can be divided into mechanical and temperature and humidity influences. Mechanical operational damage, such as punching non-design holes for ventilation or sewer networks, beating the protective layer of concrete and welding to the reinforcement of electrical networks, suspensions, etc., lead to local destruction of reinforced concrete structures.

Temperature-humidity influences on reinforced concrete structures of a covering can be only from influence of moisture during infringement of a temperature-humidity mode of a design. Reinforced concrete structures of the coating are damaged by moisture due to leakage of the roof (especially on the ends, in places of ventilation, sewer networks and drainage systems), humidification with process fluids, spills, splashes.

Violation of the temperature-humidity regime of combined roofs and roofs with a cold or warm attic leads to condensation of moisture on the surface of reinforced concrete structures (Fig. 1, a), their freezing and the formation of mold (Fig. 1, b).

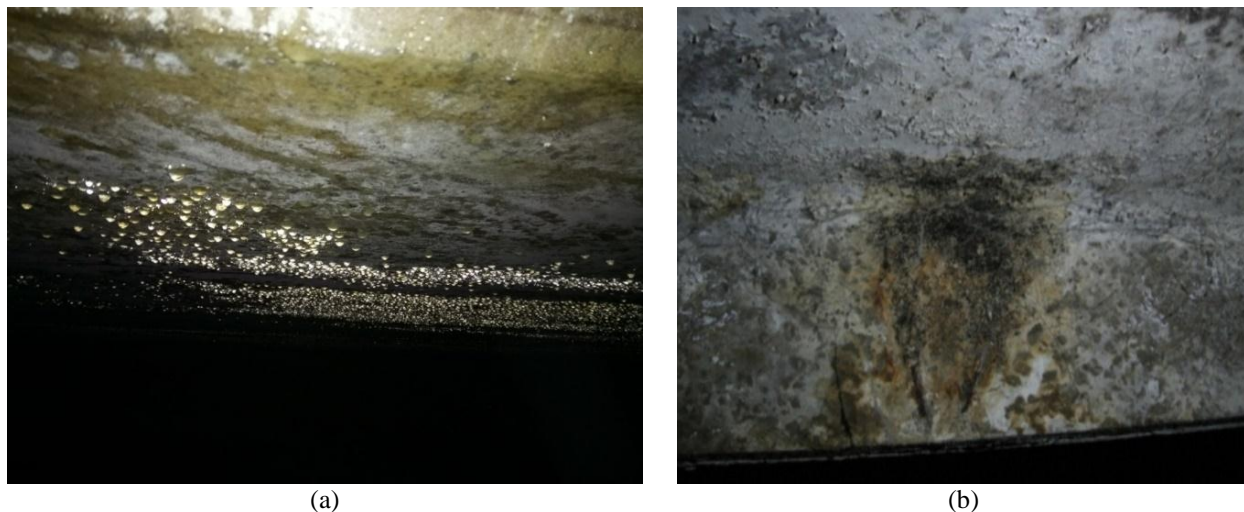


FIGURE 1. Condensation of moisture on the inner surface of the coating plate (a), and, as a consequence, the formation of black mold on the surface of the plates (b).

For flat coatings with a cold attic, the main disadvantage is the violation of the temperature-humidity and aeration regimes of the attic, which leads to humidification of reinforced concrete structures and insulation, the formation of black mold on the surface of structures. Examples of such violations are:

- insufficient thickness of the insulation in the construction of the attic floor, which leads to the outflow of warm air into the attic space from the heated room;
- destroyed ventilation system of the building in the attic, which is not removed from the structure of the floor (Fig. 2, a);
- location in the space of the cold attic of the elements of the air conditioning system (Fig. 2, b);
- violation of thermal insulation on the heating media of the heating system, located in the attic space (Fig. 2, c);
- removal of sewer riser pipes in the attic space;
- closed or glazed attic vents (Fig. 2, d).



(a)



(b)



(c)



(d)

FIGURE 2. Violation of temperature-humidity and aeration regimes of the attic: destroyed ventilation system of the building in the attic (a), location in the space of the cold attic of the elements of the air conditioning system (b), violation of thermal insulation on the heating media of the heating system, located in the attic space (c), closed or glazed attic vents (d).

CHARACTERISTIC DAMAGES OF REINFORCED CONCRETE STRUCTURES OF THE COVERING DURING OPERATION AND MEASURES FOR ENSURING THEIR FURTHER SAFE OPERATION

All these exposures lead to the development of corrosion in concrete and reinforcement. Corrosion of concrete is fixed on white salt spots (in places of flow or technological strait) (Fig. 3, a). The presence of design and non-design holes in reinforced concrete coating structures has a significant impact on the corrosion rate in concrete and reinforcement structures (Fig. 3, b, c). Corrosion of reinforcement primarily occurs in places with insufficient thickness of the protective layer (up to 10 mm) and leads to the formation of deformations places of concrete, the destruction of the protective layer of concrete, which further accelerates the corrosion of reinforcement (Fig. 3, d).

The corrosion products of the fittings have a volume 2-3 times larger than the initial steel of the product. This physico-chemical process leads to the destruction of concrete, the loss of pieces of the protective layer of concrete ribs, which can lead to injury to people under damaged panels. After destruction of a protective layer of concrete in the damp atmosphere or under the influence of straits full corrosion of armature can occur in 2-3 years that leads to destruction of a covering (Fig. 3, e, f).



FIGURE 3. Characteristic damages of reinforced concrete structures of a covering during operation: white salt spots on the concrete surface (a), corrosion of concrete and reinforcement in places of design and non-design holes in reinforced concrete coating structures (b, c), peeling of the protective layer of concrete (d), corrosion of reinforcement, leading to the destruction of concrete, the loss of pieces of the protective layer of concrete ribs (e, f).

The scheme of characteristic damages of reinforced concrete structures of a covering during operation is given in Fig. 4. Reinforcement of such ribbed panels [14], as a rule, it is carried out by supply of steel beams (Fig. 5). When 80% of the reinforcement is worn, it is recommended to dismantle the damaged coating panels.

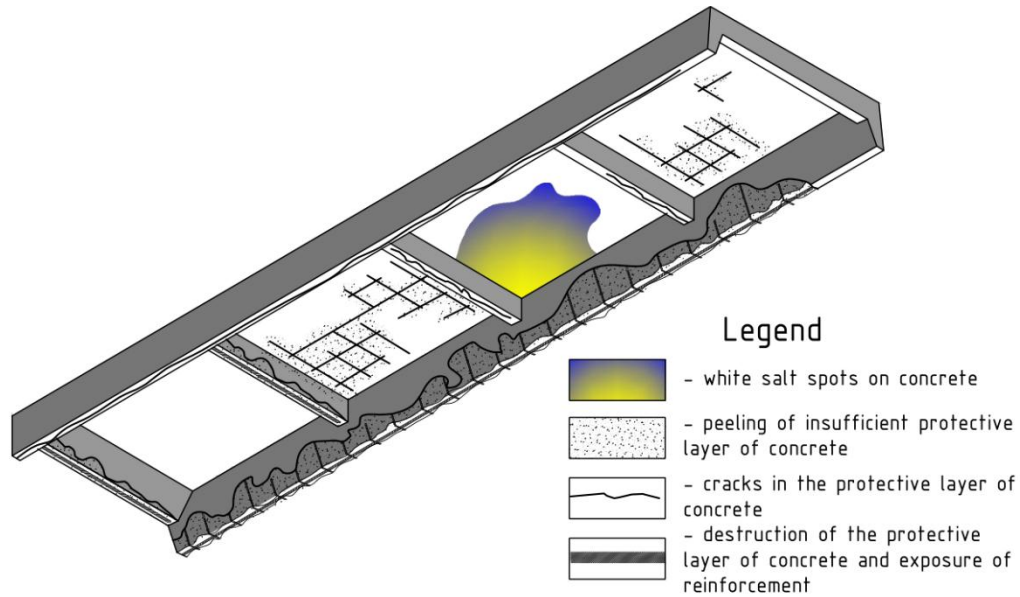


FIGURE 4. Scheme of characteristic damages of reinforced concrete structures of a covering during operation.

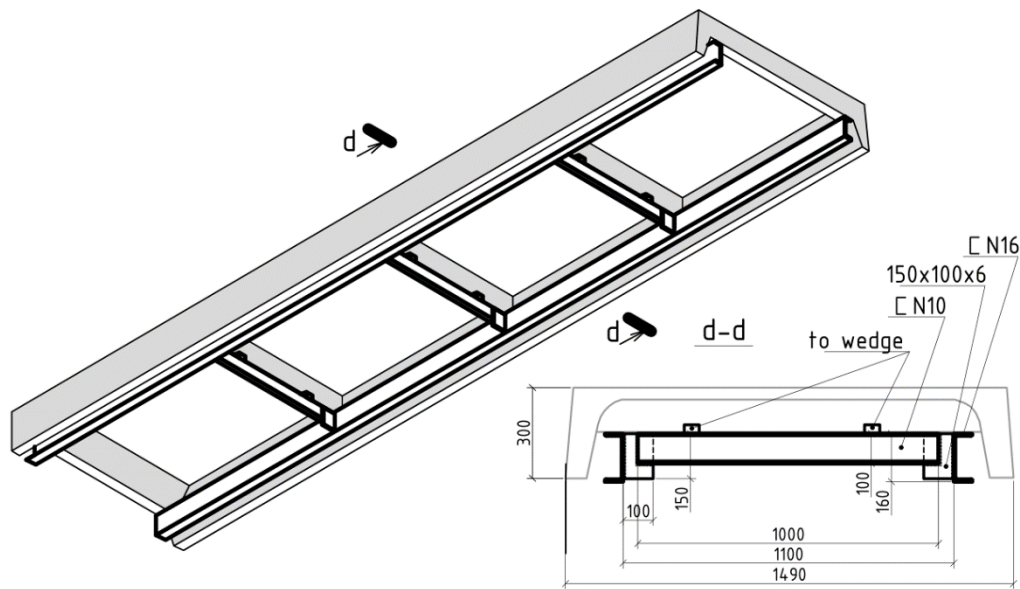


FIGURE 5. Method of reinforcing reinforced concrete structures of the coating by bringing the channels.

For the subsequent trouble-free operation after strengthening the following measures are recommended:

- restoration of the protective layer of concrete;
- restoration of vapor barrier;
- installation of new thermal insulation;
- restoration of the roofing carpet;
- elimination of leaks (near openings, network terminals, etc.).

To comply with the temperature-humidity regime of cold attics, it is recommended to open all ventilation vents in the attic walls to ventilate the attic space, prevent the accumulation of moisture in the insulation and limit the spread of black mold on the inner surfaces of the attic. It is necessary to insulate the pipes within the cold attic or move from the space of the cold attic to the heated room of the building to reduce heat loss by the heating system with the upper wiring. Ventilation ducts within the attic must be intact, and the outlets of ventilation ducts and sewer

risers must be raised above the roof level. For combined roofs, it is recommended to arrange a ventilation system of the insulation (air layers, vents with weather vanes) to exclude moisture condensation.

CONCLUSION

Operational influences on reinforced concrete structures of a covering lead to formation of damages of designs. Mechanical damage (punching of non-design holes, damage to the protective layer of concrete) will increase the temperature and humidity effects on reinforced concrete structures. These examples of violations of the temperature-humidity and aeration regime of the cold attic are quite common in the inspection of buildings and structures, so they can be considered typical. Damage to reinforced concrete structures of the coating can be eliminated by performing strengthening according to a specially designed project. However, in the case of corrosion, wear of 80% of the fittings, it is recommended to dismantle the damaged coating panels. To eliminate the causes of corrosion damage to reinforced concrete structures, it is recommended to insulate structures and bring the temperature-humidity regime of the attic to regulatory and operational requirements. Adherence to the temperature-humidity regime of combined roofs and roofs with a cold or warm attic will reduce moisture condensation on the surface of reinforced concrete structures to a minimum, which, in turn, will extend the period of trouble-free operation of reinforced concrete structures.

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