

Typical defects and damage to the industrial buildings' facades

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Abstract. During the life cycle of the industrial building, defects and damages associated with the production process or their operating conditions accumulate in the construction structures. Defects of facades, such as destruction of the protective layer of concrete, exposure of the wall panels working reinforcement, destruction of the concrete of the carnal slabs, absence of glazing on the windows, corrosion of metal fire ladders, destruction of the wall and mechanical damage to the wall panels by motor vehicles, are repeated at different objects and have common causes of occurrence. The authors have identified 5 characteristic zones of defect. The article contains recommendations for the elimination of detected defects and damages. Defects and damages are proposed to be combined according to the above groups during surveys or monitoring of façade condition. This will allow to monitor the dynamics of negative processes development and to carry out major repairs in a timely manner during scheduled annual inspections of facades.

1. Introduction

Many production facilities in our country were built in the 50s and 60s of the XX century, when active economy and construction development growth from modular reinforced concrete and metal elements occurred. Currently, many industrial buildings and structures have reached their limit of standard operating life. In the Fundamentals of the Russian Federation state policy in the field of industrial safety for the period up to 2025 and the further prospect (approved by the President Decree of the Russian Federation dated 05.06.2018 No. 198), the critical wear level of the main industrial buildings is indicated as the main source of the increased accident rate danger at industrial facilities.

2. Materials and methods

During the industrial building's life cycle in building structures, damage occurs due to the production process or operating conditions. Therefore, it is necessary to conduct an inspection of the facility and an expert assessment of the existing damage to building structures, an analysis of the accident risk at the facility, as well as the recommendations development for eliminating the detected defects and damages and bringing the building or structure to a healthy state for its further safe operation.

Recently, the SRSPU (NPI) specialists conducted a survey of a number of industrial buildings for various purposes [1 - 6] in the Southern Federal District. The facades' defects are repeated at various



objects that have common causes, which allows the analysis and systematization of defects when conducting inspections at new objects, as well as paying attention to the most dangerous areas.

Similar studies of the condition of facades made of various materials damaged by atmospheric precipitation, efflorescence, etc. were carried out abroad [5 - 12].

The industrial buildings and structures' condition is characterized by a rapid approximation of service life to the limit and an increase in the number of defects in building envelopes. Their examination is carried out in accordance with the existing regulations' requirements [7, 8]. Today, the most effective way to predict and prevent emergencies is to assess their technical condition, which is carried out constantly at the construction stages and regularly at the stage of the buildings' operation.

3. The study of the industrial buildings' typical facade

With the introduction of a number of new regulatory documents, the importance of continuous monitoring has increased. Therefore, the need to create an effective methodology for assessing the external building envelopes' technical condition based on monitoring data comes to the fore.

As a result of each monitoring stage, sufficient information should be obtained to prepare a reasonable conclusion on the current technical condition of a building or structure's facade and to issue a short-term forecast on its condition for the coming period.

For example, let us consider the industrial building typical facade shown in Figure 1.

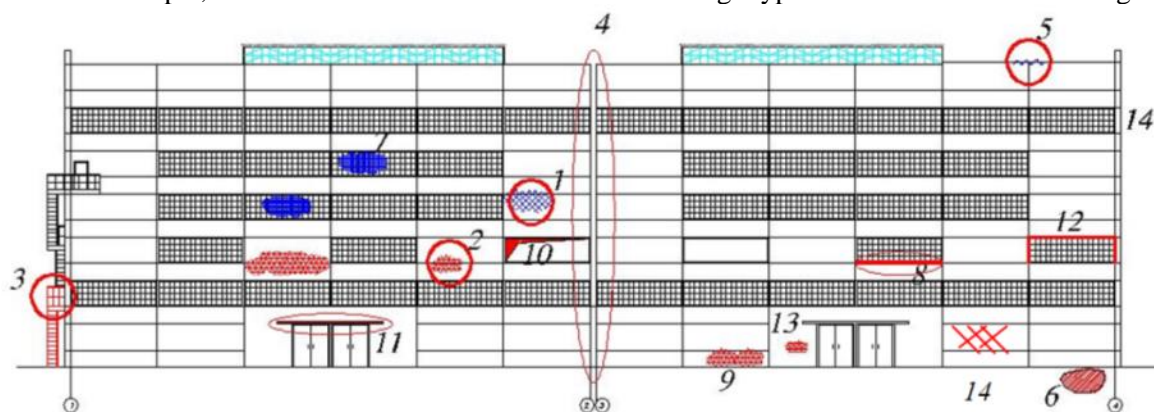


Figure 1. Typical industrial building facade: 1 and 2 – the wall panels' typical defects, 3 - a group of fire ladder defects, 4 - defects in the expansion joints areas, 5 - defects in the cornice parts of buildings, 6 - defects in the communication entry area, 7 - defects in window packing, 8 - ebb defects on the windows, 9 - poor condition of the blind area and the basement panels' soaking, damage to the lower wall panels by motor vehicles, 10 – the technological openings defects, 11 - defects of load-bearing lintels and the building entrance, 12 - lack of slopes on the windows, 13 - brick defects sewage on the buildings' facades, 14 - mechanical damage to wall panels by motor vehicles.

1 - traces of soaking precast reinforced concrete wall panels, peeling concrete without exposing the working reinforcement. During development, this damage can lead to the protective layer destruction of concrete, corrosion and destruction of the wall panel reinforcing cage. It is eliminated by cleaning with metal brushes, blowing with compressed air and plastering with cement-sand mortar or a special repair mixture for concrete.

2 - traces of soaking precast reinforced concrete wall panel with exposure and corrosion of reinforcement. Further development of corrosion and destruction of concrete will lead to the panel frame destruction and the concrete loss. It is eliminated by cleaning concrete and cleaning reinforcing bars, followed by plastering the wall panel on the damaged area with cement-sand mortar or repair mortar for concrete.

3 - damage to metal fire escape, metal corrosion, damage to steps, damage to stair railings. This damage does not significantly affect the bearing capacity of the entire production building, but significantly affects the workers' safety. Very often fire ladders in industrial buildings are used for

daily movement of people and are the only way out to the roof of the building, so damage to fire ladders can lead to the workers' falling from a height. It is eliminated by straightening or replacing the damaged elements of steel structures with subsequent painting.

4 – the expansion joints filling destruction, joints between wall panels, the loss of solution from the joints. Damage does not significantly affect the load-bearing capacity of the building, but leads to a violation of the facade integrity and the wall panels destruction from the inside when the precipitation falls. Damage is repaired by clearing the expansion joint from the destroyed packing and is hardened with glass wool or insulation followed by cement-sand mortar or plastic mixtures, however, galvanized zinc-coated sheet steel has recently been used instead of plaster.

5 - the cornice slabs destruction on the building facade, the cornice slab frame concrete and exposure destruction. Destruction of concrete can lead to falling pieces of concrete from a height, and destruction of the cornice slab will lead to the wall panels soaking. Damage is eliminated by plastering the cornice in the damaged area or by replacing the cornice if the damage is significant.

6 - defects formed after the input of communications - these are punched holes in the wall panels, the destruction of concrete in the input zone, exposure and corrosion of the wall panel working reinforcement, the blind area subsidence. These types of damage lead to the wall panel destruction and the reinforcing cage corrosion. Damage is eliminated by cleaning the damaged area, cleaning the fittings from the corrosion products and plastering with cement-sand mortar. The blind area sagging is eliminated by pouring concrete by adding asphalt concrete mix, followed by compaction. If leaks occur, they must be repaired promptly.

7 – the defects in windows and glazing are manifested in the form of broken glass, destruction and decay of wooden frames. In case the frames are metal, they can be manifested in the form of metal corrosion. Damage to windows leads to a violation of the indoor microclimate of the room and makes working conditions uncomfortable for personnel, as well as lead to the precipitation ingress into the production room. Repair is done by replacing the damaged glass, replacing or painting wooden window frames or painting metal frames. An ideal repair case is the complete replacement of window packing with a double-glazed window in a metal-plastic frame.

8 - absence, corrosion or distortion of galvanized roof steel drainages under the facades' windows. This damage leads to the precipitation leakage on the wall panel under the window, its destruction during freezing and thawing, the destruction of brickwork, if the facade is brick. Damage is eliminated by installing a new drainage system made of galvanized steel roof or plastic drainage system with minor damage straightening and the old drainage system painting is possible.

9 - soaking the basement panels and the blind area destruction around the perimeter of the building. If the pitch angle of the blind area is violated, rainfall bounces from it onto the lower wall panel, which leads to its soaking, the formation of fungus on the panel, corrosion of the reinforcement and subsequent destruction of the wall panel concrete. Damage is eliminated by pouring concrete on the blind area and giving it the desired angle of inclination, the lower wall panel is cleaned of fungus and peeling concrete, and then plastered. The blind area destruction or absence leads to the soil base soaking, foundations subsidence, the cracks appearance in the building envelope and the crane equipment disruption. In such cases, it is necessary to restore the blind area along a previously cleaned and leveled surface.

10 - technological openings defects, such as the openings steel flaps destruction or corrosion, the openings reinforced concrete frames destruction, the concrete reinforced concrete lintels destruction. Violation is similar to the destruction of the window packing, leads to a violation of the microclimate inside the building, the destruction of the wings leads to disruption of the technological equipment operation. The violation is eliminated by restoring the metal flaps, cleaning them from corrosion, painting. Concrete destruction of frame structures or reinforced concrete lintels is eliminated by plastering on a previously cleaned surface.

11 - defects of the entrance group of the building, such defects include the destruction of reinforced concrete lintels, the destruction of reinforced concrete visors above the entrance to the building, door filling and the steps destruction at the entrance. These damages lead to a violation of the building's

aesthetic appearance and to the inconvenience of its operation, the destroyed concrete of the visor may collapse on the heads of staff, and the destroyed packing of doors and steps makes the access to the production building uncomfortable. Damage is eliminated by replacing the door filling, restoration of damaged steps with concrete, cleaning and plastering of damaged visors. With a significant destruction of reinforced concrete visors above the entrance to the building, it is recommended to replace them with the metal ones.

12 - lack of the windows slopes. The causes of such damage are mechanical damage or thawing due to atmospheric precipitation. The damage development leads to the destruction of wall panels along the window openings' edges. It is eliminated by plastering on a cleaned and prepared surface.

13 – the brick inserts defects on the building facades can be the sections with defrosting and weathering of brickwork, unevenness of brickwork or bulging, separate bricks falling out, etc. Minor damage in the form of defrosting or weathering is eliminated by cleaning the surface, blowing with air and plastering. If the masonry is damaged to a depth of more than 50 mm, it is recommended to perform plastering on the reinforcing mesh. The loss of individual bricks is eliminated by their insertion on a cement-sand mortar, and the defects in the form of bulging or verticality violation are recommended to eliminate shifting the masonry to the damaged areas.

14 - destruction of wall panels caused by mechanical damage to vehicles. This damage is often found in large industrial enterprises and is associated with sloppy driving of heavy trucks in cramped conditions of dense factory development. Minor damage in the form of concrete protective layer destruction is eliminated by plastering, when breaking the reinforcement in the wall panels, reinforcement must be performed. If the wall panel breaks and the large concrete fragments fall out, the wall panel is necessary to be replaced.

4. Conclusion

The industrial buildings facades inspection results analysis made it possible to identify the characteristic zones of the most likely occurrence of defects:

Zone 1 - defects in the form of soaking and defrosting (1), leading to exposure and corrosion of the wall panels reinforcement (2 and 9), as well as to destruction of the expansion joints filling and the joints between the panels (4).

Zone 2 - defects of window packings and technological openings (10), destruction of the window frames' glazing (7), low tides (8) and the absence of slopes (12).

Zone 3 - defects of cornice plates and parapets (5), the absence of drainage from galvanized steel roofing on parapets.

Zone 4 - defects of the entrance group (3 and 11), damage to steps and visors.

Zone 5 - the blind area and lower panels damage (9), including damage from the entry of service lines (6) and brick inserts (13).

In the defective statements, when conducting the facades condition inspections or monitoring, it is proposed to combine the defects and damages according to the above groups. This will allow to track the negative processes development dynamics and timely overhaul during the scheduled annual facades' inspections.

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