Technique for Reduction of Environmental Pollution from Construction Wastes

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Abstract. The results of the research on the negative impact construction wastes have on the urban environment and construction ecological safety are described. The research results are based on the statistical data and indicators calculated with the use of environmental pollution assessment in the restoration system of urban buildings technical conditions. The technique for the reduction of environmental pollution from construction wastes is scientifically based on the analytic summary of scientific and practical results for ecological safety ensuring at major overhaul and current repairs (reconstruction) of the buildings and structures. It is also based on the practical application of the probability theory method, system analysis and disperse system theory. It is necessary to execute some stages implementing the developed technique to reduce environmental pollution from construction wastes. The stages include various steps starting from information collection to the system formation with optimum performance characteristics which are more resource saving and energy efficient for the accumulation of construction wastes from urban construction units. The following tasks are solved under certain studies: basic data collection about construction wastes accumulation; definition and comparison of technological combinations at each system functional stage intended for the reduction of construction wastes discharge into the environment; assessment criteria calculation of resource saving and energy efficiency; optimum working parameters of each implementation stage are created. The urban construction technique implementation shows that the resource saving criteria are from 55.22% to 88.84%; potential of construction wastes recycling is 450 million tons of construction damaged elements (parts).

1. Introduction
Rational use of natural resources is one of major strategic and priority tasks in social state [1-5]. In this direction Federal Laws and resolutions of the Government of the Russian Federation are actively adopted [6].
From 2010 to 2014 74,1 million tons of construction wastes were in the Russian Federation. Only 48,3 million tons were recycled and neutralized [7]. At the same time there is negative dynamic of hazardous housing formation which has to be completely repaired (reconstruction). In 1990 the area of such housing was 3,3 million sq.m and in 2015 was 19,62 million sq.m [8].
It is possible to say that construction wastes use is often an algorithm of its removal way (warehousing) for the purpose of further transportation on disposal sites and utilization (table 1). Such conclusion is made according to documentation analysis. This documentation is about building’s major overhaul and current repairs. It is also concerns buildings and structures reconstruction executed on the basis of the Russian Federation legal acts. This documentation should pass state examination.

Table 1. Ways of construction wastes treatment according to design and estimate documentation of the Russian Federation.

| Construction wastes                   | Way of construction wastes use | Way of construction wastes removal                     |
|---------------------------------------|--------------------------------|-------------------------------------------------------|
| Concrete scrap                        | Stored on a site with hard coating | –                                                     |
| Brick wastes                          | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Thinning                              | –                               | Disposal site of solid municipal wastes, fuel resource |
| Stucco scrap                          | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Quartz sand wastes                    | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Cement mortar wastes, cement wastes   | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Household garbage                     | –                               | Disposal site of solid municipal wastes               |
| Road metal, stone scrap               | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Ceramic wastes                        | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Asphalt concrete wastes               | Stored on a site with hard coating | Disposal site of solid municipal wastes               |
| Bitumen wastes                        | –                               | Disposal site of solid municipal wastes               |
| Polymer material wastes               | –                               | Disposal site of solid municipal wastes               |
| Ferrous steel scrap                   | Stored on a site with hard coating | Licensed enterprise for ferrous metals recycling      |
| Welding rods' wastes                  | –                               | Licensed enterprise for ferrous metals recycling      |

Figures given above and current state of construction production demonstrate that there is a problem of urban construction ecological safety ensuring. Such problem is connected with low use of construction wastes which are formed when carrying out major overhaul, current repairs or building reconstruction [9-11].

Initial task of described problem solution at state level is information collection (volume of construction wastes formation, position of construction sites, composition of construction wastes, the most rational ways of recycling, etc.). This information characterizes separate objects of technical restoration and current situation in general that will allow estimating negative impact on environment [12-14].

2. Results and discussions
Technique of environmental pollution reduction under building's technical restoration system is developed. It is developed for negative impact evaluation of construction wastes on environment. Main stages are described in figure 1.

Testing of this developed technique shows the following advantages:
- use of construction wastes on place of their formation;
- information availability for databank formation, i.e. to determine quantity (weight) of formed wastes when carrying out reconstruction work in buildings. It is enough to have data about damage of separate types of building structures;
- use of existing technical facilities without their modernization during recycled construction wastes use;
- flexibility in construction wastes use under recovery work.
- Testing of this developed technique is done in some Russian cities [15,16]. But there are some disadvantages of this technique:
- complexity of construction technological process;
- unstudied questions of construction wastes recycling in concrete.

Main steps of pollution reduction technique are described in implementation block diagram (figure 1) [17].

Technique of environmental pollution reduction under urban building's technical restoration system is based on the only rational variant. This choice is based on energy efficiency (Ee) and resource-saving (Er) criteria. Ee and Er criteria should be maximum [18-21].

Effectiveness of building wastes decrease system to the environment in many respects depends on their use as large and small filler during concrete mix preparation. In studied technique it is described by functional steps such as building wastes collecting, transportation, sorting, crushing and use.

Ecological (Er) and power (Ee) criteria are developed for this purpose. Physical models describing processes of building wastes existence in the environment are basis for this technique. During research studies consistent patterns of building wastes quantitative and qualitative composition are determined. This depends on degree of building structures damage (table 2).

Calculation of initial specific weight of construction wastes in urban building's technical restoration system is done by the following formula:

\[ M_1 = M_{r1} + 0.15M_{r5} + 0.25M_{r4} + M_{r5} + M_{e3} + M_{e5} + M_{w4} + M_{w5} + M_{s5} \]  

(1)

Resource saving criteria for different use of construction wastes is done by the following formula:

\[ E_s = \frac{M_2}{M_1} \times 100\% \]  

(2)

where \( M_1 \) – initial specific weight of construction wastes, kg/year; \( M_2 \) – final specific weight of construction wastes irrecoverable losses, kg/year.

This developed technique provides actions for concrete use with small and large fillers from building wastes at protective concrete layer restoration of reinforced concrete structures, bricklayer restoration, building skeleton strengthening, perimeter walk and other construction works.

Estimation criteria characterizing indicators of energy efficiency and resource saving in the process of building wastes use is calculated according to data bank (figure 2). These construction wastes are formed in transfer process of building into standard (serviceable) technical condition at major overhaul, current repairs and reconstruction.

Practical realization of developed technique for urban development shows that resource-saving criteria is from 55.22% to 88.84%.
Figure 1. Main steps of pollution reduction technique in building’s technical restoration system.
Table 2. Formed construction wastes during major overhaul, current repairs and reconstruction.

| Damage | Construction wastes, kg |
|--------|-------------------------|
|        | Stone | Reinforced concrete | Wooden | Steel |
| E=0    | 0     | 0                   | 0      | 0     |
| E=0,05 | M_{s3} | M_{c3}              | M_{w3} | 0     |
| E=0,15 | 0,15M_{s4} | M_{c4}         | M_{w4} | 0     |
| E=0,25 | 0,25M_{s5} | M_{c5}         | M_{w5} | M_{s5} |
| E=0,35 | M_{s5} | M_{c5}              | M_{w5} | M_{s5} |

According to Federal State Statistics Service in 2014 38% of houses had to have major overhaul (reconstruction), buildings total area was 3473 million sq.m (ramshackle and abnormal housing was 93,3 million sq.m) [7].

3. Conclusion

According to housing statistical data about dwelling total area and wear, buildings should be dismantling when carrying out repair and recovery works. They are included into existed 450 million tons of damaged structures. It also should be done according to practical application of recycled construction wastes use. On the other hand, in case of inactivity, building wastes will negatively influence ecological safety of construction as ecological safety component of the Russian Federation.

This developed technique implementation for major overhaul and current repairs of buildings in the Russian Federation is necessary as one of possible ways for technologies development and also for biosphere progressive harmonic development.

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