Recycling of Construction Wastes During Major Repairs

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Abstract. This article discusses the issue of recycling of construction wastes during major repairs (rebuilding operations). The complete analysis of design and estimate documentation of the Russian Federation developed on the basis of the effectual statutory instruments allows us to draw the conclusion that the definition of usage of construction wastes usually includes the algorithm of their treatment (storage) with a purpose of transportation to the spoil disposal in the future. The investigation results are based on the on-site inspections of buildings where major repairs (rebuilding operations) are necessary, statistics, system analysis and analytical correlation of known practical and scientific facts. A policy of recycling of construction wastes during major repairs (rebuilding operations) was created, which includes 5 main phases: information acquisition, formation of set of technological combinations for every performance phase, comparison of handling abilities of the formed performance phase combinations, calculation of resource-saving exponent, calculation of energy performance exponent, choosing of the technology edition, formation of the construction wastes recycling system. Analytical dependences were found where the amount of construction wastes developing from demolition of defective and damaged sections depends on technical condition of a building carcass. Also, estimation criterion of method are offered: resource-saving and energy efficiency. During the implementation of recycling the resource-saving exponent ranges from 55, 22% to 88, 84%. In virtue of statistics it can be said without prejudice that even today the territory of the Russian Federation accumulates about 451 million tons of potential construction wastes rising from major repairs (rebuilding operations). In case of non-act all the mentioned capacity will exert downward pressure on the environment.

1. Introduction
Rational use of environmental resources is one of the most important strategic and top priority aim of a modern welfare state [1-5]. For the past 10 years there are many Federal Laws and Decrees of the Government of the Russian Federation actively passed in this regard [6].

So far, technical condition of 34% of buildings where Russian citizens live are close to the state of failure and 4% of buildings are already in that state [7]. Reconstruction of existing real estate fund and improvement of the population quality of life are important problems of environmental compliance of construction and city services.

Analyzing the design and estimate documentation of major repairs (rebuilding operations) made by virtue of laws and regulations of the Russian Federations and passed the government expert review inference should be drawn that the definition of the consumption of construction wastes more often than not includes the algorithm of their treatment (storage) with a purpose of transportation to the spoil disposal in the future (table 1).
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                        | Disposal site of solid municipal wastes                    |
| Brick wastes                         | Stored on a site with hard coating                        | Disposal site of solid municipal wastes, fuel resource     |
| Thinning                             |                                                          | Disposal site of solid municipal wastes                    |
| 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           |

As of today, scientific and technical literature offers a large number of multifarious engineering activities for the restriction of environmental pollution made by construction wastes, which can be extended and submitted in a scheme (pic.1) [8-10].

Figure 1. Scheme of handling the construction wastes during major repairs (rebuilding operations).
Recycling of construction wastes during major repairs (rebuilding operations) is a complex engineer job that requests an accurate standard of operating procedure while using construction wastes as a development resource. To heighten people’s interest in this problem a huge consolidation of efforts is required from: federal and regional executive authorities; legislative authority; community bodies; scientific organizations; public associations and business community. And a policy of construction wastes’ secondary use should become one of the main results of this job.

2. Results and discussion
A policy was made for the purpose of secondary use of construction wastes during major repairs (rebuilding operations), which has a certain key milestones showed on the picture 2.

![Figure 2. Main steps of recycling technique during major repairs (rebuilding operations).](image-url)
This system of secondary use of construction wastes during major repairs (rebuilding operations) is based on choosing the only rational option from the universum of possible choices, which is founded on the basis of energy efficiency and rational use of resources criteria. The exact values of this criteria should equal its maximum performance [11-14].

In virtue of undertaken studies relations were found showing dependency of number of construction wastes from damage degree of building carcass (table 2).

For the purpose of forming the data bank on-site inspections were made inspecting buildings demanding major repairs (rebuilding operations) [15-17]. The main technical characteristics of investigated objects are: building footing — loam soil; foundation — strip; framings — brick wall; utility systems — storm drainage system, ventilation system, waterworks, canalization, heating system etc.

Calculation of technical condition \( J, \% \) was made based on results of on-site building inspections and was calculated by this formula:

\[
J = \frac{\alpha_1 \varepsilon_1 + \alpha_2 \varepsilon_2 + \ldots + \alpha_i \varepsilon_i}{\alpha_1 + \alpha_2 + \ldots + \alpha_i}
\]  

(1)

where \( \varepsilon_1, \varepsilon_2, \ldots, \varepsilon_i \) — average of damages of specific kinds of carcasses, \( \alpha_1, \alpha_2, \ldots, \alpha_i \) — coefficient of specific carcass signification.

Table 2. Equations of dependency of number of construction wastes from damage degree of building carcass.

| Range of \( J, \% \) | Equation of dependency | Figures |
|----------------------|------------------------|---------|
| 67-71                | \( M_{\text{overall}} = 10^{6,3574 - 0,0577 \cdot J} \) | Correlation ratio 0,998 |
| 71-81                | \( M_{\text{overall}} = 1444,0774 /(-63,0368 + J) \) | Pearson coefficient 0,9917 |
| 81-88                | \( M_{\text{overall}} = 567,8706 - 5,966 \cdot J \) | Pearson coefficient 0,9939 |
| 88-94                | \( M_{\text{overall}} = 373,9239 - 3,7598 \cdot J \) | Pearson coefficient 0,9883 |

Achieved empirical dependencies about examination of amount of construction wastes generated from demolition work made on defective and broken sections allows us to make a tentative assessment, forecast and planning of events for usage of construction wastes during major repairs (rebuilding operations) [18].

Criteria of efficient use of resources for different variations of construction wastes usage is calculated as per the:

\[
E_r = \frac{M_2}{M_1} \cdot 100\%.
\]  

(2)

where \( M_1 \) — initial specific weight of construction, kg/year; \( M_2 \) — final specific weight of the used construction wastes including non-recoverable losses, kg/year.

The special feature of developed method is that preliminary estimate and forecast of amount of construction wastes (\( M_j, \) t/year) is possible during diagnosis of building’s technical state.

Practical approbation of the method for buildings placed in Rostov region revealed that ecological effect of recycling the construction wastes during major repairs (rebuilding operations) from 1 \( m^3 \) of buildings reaches from 0,25 to 3 €.

Practical realization of method for objects of urban area showed efficient use of resources criteria ranged from 55,22% to 88,84%.

Based on Federal State Statistics Service of Russian Federation report in 2014 38% of domestic buildings are requiring major repairs (rebuilding operations), where floorage comes up to 3473 mil. \( m^2 \) where 93,3 mil. \( m^2 \) are dilapidated or failing.

3. Conclusion

In the authority of statistics it can be said that even today the territory of the Russian Federation

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accumulates about 451 million tons of potential construction wastes rising from major repairs (rebuilding operations). In case of non-act all the mentioned capacity will exert downward pressure on the environment.

Usage of suggested recycling method for construction wastes during major repairs (rebuilding operations) of buildings placed on the territory of the Russian Federation is one of the possible ways of progressive and harmonious development for people, technologies and regional biosphere.

4. References

[1] Ilyichev V A 2013 Biosfernaya sovmestimost printsip, pozvolyayushiy postroit paradigm zhizni v planetom c cheholov, region, tehnologii l 4-5
[2] Bakaeva N V 2010 K postanovke zadachi upravlenija sistemami zhiznebespechenija goroda na osnove koncepcii biosfernoj sovmestimosti [Tekst] Sb. mat. VII Krymskoj Mezhunarodnoj nauchno-prakticheskoy konferencii «Geometricheskoe i komp’juterno modelirovanie: jenergosberezhenie, jekologija, dizajn» (g. Simferopol’, Nacional’naja akademija prirodoohrannogo i kurortnogo stroitel’stva, 27 sentjabra - 01 oktjabra 2010 goda) 423-427
[3] Eliseeva T P 2013 Sovremennye problemy razvitija social'no-jeekonomicheskikh i jekologicheskikh sistem [Tekst]: Monografija, pod obshhej red. Eliseevoj T.P.: ShAHTY, ISOIP (filial) DGTU 291
[4] Magomadova H A 2012 Problemy social'no-jeekologo-jeekonomicheskoy jeffektivnosti vzaimodejstvija obshhestva i prirody Inzhenernyj vestnik Dona 1 URL: http://www.ivdon.ru/archive/n1y2012/666
[5] Forbes R McDougall, Peter R White, Marina Franke, Peter Hindle 2009 Integrated Solid Waste Management: A Life Cycle Inventory 513 URL: ru.bookzz.org/ireader/780419
[6] Postanovlenie Pravitel’stva RF ot 16.02.2008 N 87 (red. ot 26.03.2014) "O sostave razdelov proektnoj dokumentacii i trebovanijh k ih soderzhaniju"
[7] Zhilishhnoe hozjajstvo v Rossii 2013 Stat. sb. Rosstat 72 20
[8] Goponov V L, Shevchenko I S 2006 Sbor i utilizacija tverdyh othodov po treblenija v Rostove-na-Donu Pravovye voprosy ohrany okruzhajushhej sredy: jekspress-informationa 3 14-19
[9] Vajsman Ja I, Korotaev V N, Sljusar' N N 2012 Upravlenie othodami Sbor, transportirovanie, pressovanie, sortirovka tverdyh bytovyh othodov 236
[10] Rossinskaja M V, Rossinskij N P 2013 Rezul'taty teoreticheskikh i jekperimental'nyh issledovanij, poluchennye pri jekologo-socio- jeekonomicheskom monitoringe Rostovskoj oblasti, po obezvrezhivaniju othodov s cel’ju ih ispol’zovanija Inzhenernyj vestnik Dona 4 URL: ivdon.ru/russian/archive/n4y2013/1926
[11] White R R 2002 Building the ecological city Cambridge: Woodhead Publishing Limited 239
[12] Bespalov V I 1997 Fiziko-jenergeticheskaja koncepcija opisanija processov i proektirovanija inzhenernyh komplexov zasnityh vozдушnoj sredy BZhD. Ohrana truda i okruzhajushhej sredy. Rostov-na-Donu: RGASM 65-70
[13] Bespalov V I, Paramonova O N 2012 Fizicheskaja model’ processa zagrzajnenija okruzhajushhej sredy tverdrymi othodami potreblenija Inzhenernyj vestnik Dona 4 URL: ivdon.ru/archive/n4p1y2012/11/
[14] Paramonova O N 2013 Rasmoctrenie tverdyh othodov potreblenija kak dispersnoy sistemy Inzhenernyj vestnik Dona 3 URL: ivdon.ru/archive/n3y2013/1933/
[15] GOST 31937-2011 «Zdanija i sooruzhenij. Pravila obsledovanija i monitoringa technicheskogo sostojanja»
[16] SP 13-102-2003 «Pravila obsledovanija nesushhix stroitel'nych konstrukcij zdаний i sooruzhnenij».
[17] Dobromyslov A N 2001 Rekomendacii po ocenke nadezhnosti stroitel'nych konstrukcij zdanij i sooruzhnenij po vnesnim priznakam Moskva: Cnippromzdanij 72
[18] Klimenko M Ju, Kasharina T P 2014 Zagrzajnenie territorij gorodskoj zastrojki valovymi vybrosami v atmosferu i othodami pri stroitel’stve Jekologija urbanizированных территорий 4 S 68-70
[19] Sonesson U 2000 Modelling the waste collection - a general approach to calculate fuel consumption and time Waste Management & Research 18 115-123

[20] Federal'nyj Zakon ot 24.06.1998 № 89-FZ (red. ot. 31.12.2017) «Ob othodah proizvodstva i potrebleniya» (s izm. i dop., vstup. v silu s 01.01.2018)

[21] Federal'nyj Zakon ot 30.03.1999 № 52-FZ (red. 29.07.2017) «O sanitarno-ehpidemiologicheskom blagopoluchii naseleniya» (s izm. i dop., vstup. v silu s 30.09.2017)

[22] 2013 Monte Morin Study: Air pollution causes over 2 million deaths a year Los Angeles Times, URL: articles. /2013/jul/12/science/la-sci-sn-air-pollution-causes-more-than-2-million-deaths-a-year-20130711

[23] Technical and economic study of Incineration Processes Department of the Environment, Warren Spring Laboratories, Stevenage, UK

[24] Choice of Material and Quality Control, Landfill Completion and Aftercare, Environmental Monitoring, Third International Landfill Symposium, Sardinia, 14-18 October, pp 951-960

[25] WCED. 1987 Our Common Future World Commission on Environment and Development, Oxford University Press, Oxford, 1987