Quality assessment of urban environment

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Abstract. This paper is dedicated to the research applicability of quality management problems of construction products. It is offered to expand quality management borders in construction, transferring its principles to urban systems as economic systems of higher level, which qualitative characteristics are substantially defined by quality of construction product. Buildings and structures form spatial-material basis of cities and the most important component of life sphere – urban environment. Authors justify the need for the assessment of urban environment quality as an important factor of social welfare and life quality in urban areas. The authors suggest definition of a term “urban environment”. The methodology of quality assessment of urban environment is based on integrated approach which includes the system analysis of all factors and application of both quantitative methods of assessment (calculation of particular and integrated indicators) and qualitative methods (expert estimates and surveys). The authors propose the system of indicators, characterizing quality of the urban environment. This indicators fall into four classes. The authors show the methodology of their definition. The paper presents results of quality assessment of urban environment for several Siberian regions and comparative analysis of these results.

1. Introduction
The quality management has recently become a crucial component of economic systems management. The sphere of quality management mainly includes production systems with the quality of processes, goods or services as the objects of management. It is valid for construction industry as well where practically all large enterprises have created corporate systems of quality management. It allows them increasing competitiveness of construction production in the market. Nevertheless, problems of quality management in construction continue to be extremely relevant because characteristics of construction product often do not satisfy the requirements of consumers. This is not only due to the level of design solutions or quality of materials and structures, but this is also connected with following regulatory requirements under work execution. In particular this is proved by the inspections of the state construction supervision in the Tomsk region (in 2011-2013 every fifth or sixth investigated object in the construction or reconstruction of the Tomsk Region has detected violations) [1].

Therefore research of quality management problems of construction products still takes an important place in the Russian economic science. However, in our opinion, it is necessary to expand quality management borders, transferring it principles to economic systems of higher order, in particular, on urban systems and on their separate elements. Substantially qualitative characteristics of urban system are defined by quality of the construction products which form space-material basis of the cities and the most important component of life environment – the urban environment.
2. Urban environment as an element of urban system

The global urbanization demands more attention to the urban areas, where concentrates not only considerable part of the population of planet, but also the main part of productive forces [2, 3]. The modern cities are polyhierarchical urban systems, which include social, economic and ecological subsystems. One of the most important function of urban system is formation of the life environment. Socio-political, demographic and migratory processes, investment appeal of the territory and, eventually, dynamics of city development substantially depend on quality of the life environment.

The quality of life environment is studied by many Russian and foreign researchers, but from viewpoint of ecology and human hygiene predominantly. In particular researches of scientists from the A.N. Sysin Institute of Human Ecology and Hygiene of the Environment are devoted to these problems. Some scientists use such parameters as percent of built-up area and open spaces, population and household density, accessibility to roads, quality of air and noise pollution [4], some scientists consider additionally coastal pollution, slums [5] or surface temperature [6]. Experts of United Nations Environment Programme, the Cities Alliance and the International Institute for Environment and Development show that environmental resources are the “strategic assets” for the cities [7]. However dominating of artificial urban environment and increasing its impact on all spheres of human life becomes more and more evident in modern urban systems.

Authors state that the urban environment is anthropogenous part of environment formed by set of construction objects (residential, public, industrial buildings and structures, commercial facilities, objects of transport and municipal infrastructure) and adapted natural elements of the territory. They all function in interrelation as uniform urban system and people directly interact with this unique urban system while living, forming and changing the environment. The urban environment is an element of urban system that defines the quality of the life environment, and, eventually, quality of life of the population living in urban areas. Confirmation of it is that the United Nations, estimating an index of city prosperity (City Prosperity Index) [8], as one of private indicators, considers city infrastructure which is the most important element of the urban environment.

3. Methodology

Quality management of construction products is carried out at the level of the construction organization. The basic of methodology is object-process approach. However this approach is not applicable when assessing the quality of urban environment as a result of the whole construction sector activity. It is mainly defined by the quality of building materials, the units, the performed works, individual buildings and their complexes appearing integrally and mattering exactly in that measure as it provides favorable, comfortable conditions for life environment. The peculiarity of quality assessment of urban environment is determined by the urban environment being the emergent system with its quality depending not only on quality of its individual elements, but also on level of interrelations between components. In this regard, along with the quality assessment of individual elements it is necessary to estimate and control quality of all urban system and the urban environment as set of construction projects in particular.

The quality of the urban environment is latent property, i.e. it cannot be measured directly and is developed as a result of a certain combination of a number of private characteristics which this property depends on. The quality of the urban environment is a category difficult for assessment, which is characterized not only by objective indicators, which are defined by normative documents and technical rules, but also by many subjective characteristics depending on preferences of the individual. In such a way, a basis of methodology for the quality assessment of urban environment should be based on an integrated approach proposed by the authors [9], which is suggesting a system analysis of all factors and use of both quantitative methods of assessment (calculation of particular and integrated indices) and qualitative (expert assessments, and surveys).
4. Methods of urban environment quality assessment

Quality of the urban environment is a correspondence of the urban environment with modern requirements of the individual to comfortable, favorable and safe conditions of life where humans satisfy their needs for housing, access to health care and education, movement, physical, social and cultural development, accumulation and generation of the human capital provided.

When considering the urban environment as uniform object, indicators of it quality can be divided into four categories (Table 1).

| Category of quality of the urban environment | Indicator set of quality of the urban environment | Indicators |
|---------------------------------------------|-----------------------------------------------|------------|
| Housing per capita                           | $H = \frac{S_h}{N}$,                           |            |
| Providing with social facilities             | $P_s = \frac{Q_{s_i}}{1000}$,                 |            |
| Providing with sports facilities             | $P_{sp} = \frac{Q_{sp}}{1000}$,               |            |
| Providing with cultural establishments       | $P_{cj} = \frac{Q_{c_j}}{1000}$,              |            |
| Providing with facilities of the communal infrastructure | $P_{ck} = \frac{L_k}{1000}$, |            |

- $S_h$ – total residential space, m$^2$;
- $N$ – number of inhabitants, pl.
- $Q_{s_i}$ – provision of type $i$ of social facilities;
- $Q_{sp}$ – quantity of sports facilities;
- $Q_{c_j}$ – quantity of type $j$ of cultural establishments: museums, theatres, club-type cultural institutions, parks for cultural activities and rest, zoological gardens;
- $L_k$ – length of type $k$ of communal objects, km: water supply lines, sewerage and steam network, heating network;
| Category of quality of the urban environment | Indicator set of quality of the urban environment | Indicators |
|---------------------------------------------|-------------------------------------------------|------------|
| Providing with transportation routes         | $P_{T_{i}} = \frac{M_{i}}{N} \times 1000$        |            |
| N – number of inhabitants, pl.              |                                                 |            |
| State of capital construction project       | $w_{i} = 1 - \frac{S_{l}}{S_{h}} \times 100\%$  |            |
| Housing improvements                        | $BD = \%$ of total area of slum and dangerous dwelling |            |
| Housing stock which is unequipped with      | $EE = \%$ of total area with class of energy performance “C” and higher |            |
|专家意见在0至1范围内 | | | |
| Sanitary-ecological characteristics of      | $D_{g} = \frac{S_{g}}{N}$                       |            |
| built-upness                                | $S_{g} = \%$ of total area of green planting |            |
| Built-upness                                | $K_{b-u} = \frac{S_{b}}{S_{l}}$                 |            |
| Environmental friendliness of construction  | Expert estimates in scale from 0 to 1 inclusive |            |
| Expert estimates in scale from 0 to 1       | Architectural characteristics of building       |            |
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The first two categories are the basic characteristics of urban environment quality, as they reflect providing with basic facilities for the life and the state of these objects. These indicators are quantifiable and allow for inter-regional comparisons. Tables 2 and 3 show the results of the quality assessment of urban environment made for Siberian regions. As indicators have different units of measurement, comparability was provided by normalizing according to the formula of linear scaling.

**Table 2.** The map of region positioning in terms of indicators of providing with the main capital construction objects.

| Indicator                                  | Value | 0   | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1   |
|--------------------------------------------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Housing per capita                         |       |     |     |     |     |     |     |     |     |     |     |     |
| Providing with social facilities           |       |     |     |     |     |     |     |     |     |     |     |     |
| Providing with transportational routes     |       |     |     |     |     |     |     |     |     |     |     |     |
| Providing with facilities of the communal infrastructure |       |     |     |     |     |     |     |     |     |     |     |     |

The analysis of results allows revealing the most and the least developed elements of the urban environment in each region, and, according to authors, it is important for determination of priority of the budgetary financing. For example, represented data shows that Omsk Region is one of leaders of housing per capita and providing with facilities of the communal infrastructure, Tomsk Region is the leader of providing with social facilities. The total deviation of providing lines to the left shows that urban areas have deficit of social facilities and transportational routes against the background of growing housing space. Indicators of the state of urban environment’s objects (Table 3) is far less in Omsk region than in the neighboring regions, and Tyumen region is one of the leaders. Tomsk region has average values of indicators of urban environment quality.

5. **Conclusion**

The urban environment defines conditions of person’s daily life and quality of life of the population on the urban area. Development of methods to assess urban environment quality is relevant, as the urban environment is the most important characteristic of urban system. The quality of urban environment is a multifactor category, which is subject to integrated assessment by authors system of the indicators. The analysis of assessment allows positioning the regions in terms of urban environment quality, to make interregional comparisons and to correct urban and budgetary activities.
| Table 3. The map of region positioning in terms of indicators of housing facilities state. |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Indicator                        | 0                              | 0,1                             | 0,2                             | 0,3                             | 0,4                             | 0,5                             | 0,6                             | 0,7                             | 0,8                             | 0,9                             | 1                               |
| Amount of slum and              |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| dangerous dwelling              |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with cold-water      |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| supply system                   |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with hot-water       |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| supply system                   |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with canalization    |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with heating system  |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with baths (shower)  |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with gas-supply      |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| system                          |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Part of housing stock which is |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| unequipped with electric        |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| cookers                         |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |

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