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Identification Aspects and High-Risk Areas Evaluation During City General Plan Development Design

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Abstract: The city territory is characterized by inequality on potential influence of dangerous manufacturing objects. The current anthropogenic situation analysis and variations of hazardous manufacturing plants location, determination of population safe living are important components of city general plan development design procedure. The development of planning methodology for the identification and evaluation of potential risk areas of hazardous manufacturing plants is necessary for pre-project analysis of problem solving and specific land use in order to identify problem areas (high-risk areas). This technique will increase the level of human safety during city general plan designing.

Key words: The territory of increased risk, city general plan, dangerous manufacturing objects, level of anthropogenic risk, city territory, design procedure

INTRODUCTION

City territory is the basis of urban community existence. All elements of city infrastructure are placed on it. Uneven distribution of potentially dangerous objects within the urban area leads to the fact that the level of influence within the various functional areas is unequal, synergistic effect is possible. Influence level account is needed in dealing with functional zoning. Assess the level of danger of the territory and make informed decisions on the functional zoning of the development of the master plan of the city depends on the life and health of the population, territorial development of the city. Life and health of people, territory development of the city depends on evaluation of territory danger level and from making reasoned decision on the functional zoning of city general plan development. High-risk areas are warning for almost all countries because of the universality of emergency laws, their scale. They testify to the risks posed by malfunctions of mechanisms of large enterprises for living and life of the urban population because there are no safe production objects worldwide. Technological catastrophes as a rule do not give an accurate description of their behavior because of many unpredictable aspects. According to emergency services in the country every year there is quite a large number of large-scale anthropogenic emergency situations, growth of which in some regions is up to 10% per year. Numbers of fatalities and injuries, property damage and environmental impact have increased significantly (Faleeva, 2001). The current situation is a stimulus to protection systems development of population from the imminent danger. This determines the need for the prediction of an emergency nature in urban planning for the resettlement of non-susceptibility to risk urban areas.

MATERIALS AND METHODS

The territory of city is characterized by inequality on potential impact of dangerous manufacturing objects. However, life and health of population, territorial development of city while deciding questions about functional zoning depend on assessing the level of danger territory and potential influence of dangerous manufacturing objects. Analysis of current anthropogenic situation and options of dangerous manufacturing objects dispose, determining the level of population safe living, according to the researchers are important components of the design techniques of the city general plan. Now a days, experts in civil defense pay attention to the problem of risk and prediction of emergency phenomena and emergency situations (Bennett and Ang, 1986; Evans, 1957; Pate-Cornell and Boykin, 1987; Dries, 1979; ILO, 1988). Kruglov and Tolstova (1999) and Kruglov (2000)

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considered territories subjected to the potential risk of dangerous manufacturing objects in the national urban development. The study is consisted in identifying risk areas from dangerous manufacturing objects during emergency situations of anthropogenic character. However, in urban design identification and assessment of high-risk areas was absent. In analyzing and risk management in major cities should be involved as much as possible specialists of different professions and first of all urban planners. Methods of urban planning should include questions about population safety level. Measures to city protection from the effects of emergency situations of anthropogenic character must become a fundamental in design technique of city general plan. Obviously, the main question in city planning a satisfactory settlement of the population on its territory in cities turns into complex problem, taking into account territory deficit and belonging to the particular owner (Shirina and Kononova, 2014).

The purpose of this study is to develop urban planning methodology for the identification and evaluation of potential risk areas for solving pre-project analysis and functional zoning. In this case, the most significant is the territorial approach which is implemented by anthropogenic zoning with the certain anthropogenic modes establishment in different zones of land use. Zoning in the level of potential risk reveals the problematic situations and areas of (anthropogenic environment or condition of the individual components, differing in high-risk). Territorial approach "runs through" essentially all stages of the procedure of accounting high-risk areas in cities design. Ranking problem areas on the level of technical risk will allow to identify priority measures in reducing potential risk to develop concrete proposals and to identify ways of their implementation, identification and evaluation of potential risks should be made jointly with specialists of civil defense and emergencies parallel to analysis of the territory and present state of municipal services, resettlement, technical infrastructure, technological scheme of the complex anthropogenic estimate must be made before completion functional zoning scheme.

RESULTS AND DISCUSSION

It was found that at present unified classification of cities based on account of potential influence of dangerous manufacturing objects on environment and was not developed. As a rule, the level of such effects in different functional areas of the city is not the same, so it can appear in different ways and cause a synergistic effect (Perkova *et al*., 2000; Perkova and Kruglov, 2004a, b). Some changes in the socio-political system, new trends in economics and management, current status of dangerous manufacturing objects of cities were taken into account during revelation method developing of high-risk areas. In this regard, the basic anthropogenic principles of settlement forming systems on the territory of cities are:

- Choice of location depending on the level of anthropogenic dangerous to accommodate resident population
- Settlement concentration increasing within permissible limits specified by city territory differentiation according the level of anthropogenic risk
- Selection of urban planning decisions taking into account limitation of anthropogenic loading on residential areas due to significant material damage and a potential large number of possible human toll

Territory definition on the level of potential influence of dangerous manufacturing objects should meet the following requirements:

- To take into account basic conditions of potential influence of dangerous manufacturing objects the number of stored, processed or transported of dangerous substances and the depth of destruction during technological catastrophe
- To define the urban areas prone to potential exposure of dangerous manufacturing objects and to differentiate it
- To determine the level of potential influence of dangerous manufacturing objects using quantitative indicators
- To take into account corrective urban conditions: lay of land, height and building density
- To satisfy requirements to urban design stages
- To be effective (to give a certainty with a minimum number of operations)

Based on the above requirements it was developed structural and logical model and were identified major methodological requirements, according to which we can develop a methodology for high-risk areas identifying and evaluating.

It was found that the results of evaluations and complex analysis of technical risk level can be represented as a complex schematic maps at the scale of the main drawing.

The developed method of identifying and evaluating the territories subject to the potential impact of dangerous manufacturing objects on the level of anthropogenic risk, involves several steps.

The basic condition of the potential impact of dangerous manufacturing objects is the amount of information stored, processed or transported dangerous

substances and the depth of injury in the event of emergency. In this regard, at the first stage we can define zones of possible damage in the event of emergency at dangerous manufacturing objects by equation:

$$S_{ij} = \rho \times G_{ij}^2$$

where, G_{ij} damage depth during technological catastrophe at dangerous manufacturing objects (on estimated procedures of civil defense and emergencies). Determination of the depth zone with a threshold toxic dose is defined by the following weather conditions: inversion, wind speed 1 m sec^{-1}, air t 200°C, wind direction from 0-360°. The calculated area of destruction of potentially dangerous objects is sequentially applied to city scheme:

Potential influence of chemically dangerous objects in the city: Hitting areas during emergency occurs on chemically dangerous object-radius equal to the depth of the cloud polluted air spread.

Potential influence of explosive and fire-hazardous objects in urban areas: Hitting areas during emergency on explosive and fire-hazardous object-radius equal to the amount of potential energy that can be realized in the form of explosions and fires as a result of use, processing, storage or transportation of flammable, combustible or explosive substances. Safeguard zone from pipelines is 150-350 m on both sides of the road in crowded places, 125-300 m outside.

Potential influence of railway objects on cities territory: Hitting areas during emergency on hazardous objects located on railway:

- From gravity yards on railway stations and platforms within the city limits-radius equal to the depth of the cloud polluted air spread or amount of potential energy that can be realized in the form of explosions and fires resulting from transport or storage of flammable substances
- From railway transport-width of the sanitary protection zone is at least 100 m, measured from the axis of last railway

It was found that for determining danger level of inside formed zones it is necessary to give each impact the coefficient of anthropogenic danger territory.

At the second stage each effect takes coefficient of territory of anthropogenic danger. In the study, each effect takes a relative coefficient based on objective possibility reasons of accidents: 1.0-toxic agents hitting areas, 0.8 for the hitting areas in accidents at railway stations, 0.6 for hitting areas from fires.

In this study, we put into scientific use the term coefficient of territory anthropogenic danger (researcher) coefficient which reflects the level of potential effect of one or more dangerous manufacturing objects, acting simultaneously on a particular part of a city.

It was suggested that the level of territory anthropogenic danger depends on the size of potential effect of dangerous manufacturing objects with respect to the permissible area of city destruction (3rd degree of territory danger according civil defense and emergencies -20% of the city):

$$k_{ij} = \frac{S_{ij}}{S_{per}}$$

Where:

S_{ij} = Area of burst during emergency situation

S_{per} = Permissible area of city territory under effect during emergency situation on dangerous manufacturing objects (3rd degree of territory danger according civil defense and emergencies 20% of the city)

i = Number of dangerous manufacturing object by a factor

j = Factor number

Part territory classification getting into the danger zone is proposed on the territory level classification base of the potential anthropogenic danger of dangerous manufacturing objects:

$$K^1_{cr} = \frac{S^1}{S_{per}} = 1$$

Where:

K^1_{cr} = Coefficient of critical value of 3rd degree of territory danger according civil defense and emergencies not >20% of the city

S^1 = 20% city territory

S_{per} = The 20% share city territory in potential risk zone (3rd degree of territory danger according civil defense and emergencies)

$$K^2_{cr} = \frac{S^2}{S_{per}} = 1.75$$

Where:

K^2_{cr} = Coefficient of critical value of 3rd degree of territory danger according civil defense and emergencies (area of potential defeat not >30% of the city territory)

S^2 = The 30% part city territory in potential risk zone (3rd degree of territory danger according civil defense and emergencies)

$$K^3_{cr} = \frac{S^3}{S_{per}} = 2.5$$

Where:

K^3_{cr} = Coefficient of critical value of 1st degree of territory danger according civil defense and emergencies (area of potential defeat >30% of the city territory)

S^3 = The 50% part city territory in potential risk zone (1st degree of territory danger according civil defense and emergencies)

It was found that introduction of correction factors developed by the research, allow to take into account urban characteristics of urban environment, affecting the spread intensity of potential impact: lay of land, height and building density:

$$\kappa_{ij} = \frac{S_{ij} \times \kappa_H \times \kappa_p \times \kappa_h}{S_{per}}$$

Where:

κ_H = Correction factor taking into account lay of land

κ_P = Correction factos taking into account building density

κ_h = Correction factor taking into account building height

Correction factor taking into account lay of land depends on area height within the range of dangerous manufacturing object action in comparison with mean altitude of the area in the city. Calculation of mean altitude within the boundaries of the potential impact of each dangerous manufacturing object is based on the use of graphical method to the definition of average height for each mth square:

$$k_H = \frac{H}{H_i}, \; H_i = \frac{\sum_{m=1}^{N} H_m}{N}$$

Where:

H = City area mean altitude above-sea level

H_i = Area mean altitude within boundaries of dangerous manufacturing object action

i = Number of dangerous manufacturing object

H_i = Area mean altitude (lay of land) above-sea level within boundaries of every dangerous manufacturing object action

H_m = Average height for mth square

N = Number of squares on city plan

The coefficient taking into account the population density represents the ratio of the average population density of a city to the population density within the boundaries of the impact of each dangerous manufacturing object. When calculating the average population density we compare the average population density of a city with a population density within the boundaries of the potential impact of dangerous manufacturing object:

$$P_i = \frac{\sum_{k=1}^{N} S_k}{S}, \; k_P = \frac{P_i}{P}$$

Where:

P = Average population density of a city

P_i = Average population density within the boundaries of dangerous manufacturing object

S_k = Buildings area

S_i = Average population density within the boundaries of the potential impact of dangerous manufacturing object

The coefficient taking into account the height of a building, reflects the attitude of the average height of buildings in a city to the average height of buildings within the boundaries of the impact of dangerous manufacturing object. At the same time, the average height of buildings is equal to the arithmetical mean average height of buildings within the boundaries of the potential impact of each dangerous manufacturing object:

$$k_h = \frac{h_i}{h}, \; h_i = \frac{\sum_{k=1}^{N} h_k}{N}$$

Where:

h_i = Average height of buildings in a city

h = Average height of buildings within the boundaries of the potential impact of each dangerous manufacturing object

h_k = Height of a separate building

N = Number of buildings

Evaluation of area on level of anthropogenic hazards for each of the three factors is performed on the third stage. It becomes possible to city differentiation by groups of factors. To determine the degree of importance of each factor, city territory differentiation is made by toxic effects in an emergency on a chemically dangerous object on the damaging effects during the emergency on explosion hazard object, according to the damaging effects of toxic agents and in an emergency on railway. To evaluate the qualitative states through quantitative indicators in determining the level of danger territory qualimetric method is used. On the fourth stage, based on indicators derived from the evaluation of urban planning area, complex index is defined by the equation:

$$d_i = \sum_{j=1}^{n} K_{ij} \gamma_j$$

Where:

d_i = Area actual assessment by a factor

K_{ij} = Coefficient of the area level danger

i = Area number

j = Factor number
n = Factors quantity
γ_j = Factor priority

According to civil defense and emergency situations all dangerous manufacturing objects are considered equally dangerous.

It was found that depending on the tasks at the level of technical risk assessment methods may be used partially (identification and assessment of risk from one group of factors or their elements) and thoroughly (comprehensive assessment of the investigated area of a city). Scenarios identify and high-risk areas assess, depending on the stage of developed urban design were identified.

Thus, the necessity of taking into account in urban planning high-risk areas which is determined by the growing demand for improving the safety and life of the population in major cities of the Russian Federation was established. Analysis of the experience of the development plan of the city revealed that in urban design with pre-project analysis there is no assessment of the level of potential areas of risk from dangerous manufacturing object. The existence of large areas prone to potential risk in emergency situations at dangerous manufacturing object that exceed the dimensions of industrial zones with sanitary protection zones at least 2 times were determined. These areas are suggested to call the high-risk areas.

CONCLUSION

It was developed the classification of cities in terms of areas of potential risk for inclusion in the high-risk classification of anthropogenic planning restrictions:

- Relatively favorable areas (characterized by the coefficient of area danger level from 0-1)
- Unfavorable areas (characterized by the coefficient of area danger level from 1-1.75)
- Ultra unfavorable areas (characterized by a coefficient level of area danger level from 1.75-5)

Coefficients assigned to territories depend on radius of potential impact of dangerous manufacturing objects. Major methodological requirements that allow to develop an algorithm of methodical sequence of identifying and evaluating high-risk areas was formulated:

- Basic conditions account of potential impact of dangerous manufacturing objects (number of stored, processed or transported hazardous substances)
- Differentiation of the territory with the help of quantitative indicators, definition of the level of potential risk
- Corrective conditions accounting (lay of land, height and building density)
- Stages accounting of urban design

On the basis of the basic methodological requirements it was developed urban planning method to identify and assessment of high-risk areas which allows to differentiate the level of the territory of a city of potential anthropogenic risk. The usage of given method during designing city development plan will raise human safety.

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