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Table Of Content

Journal Cover 2
Author[s] Statement 3
Editorial Team 4
Article information 5
Check this article update (crossmark) 5
Check this article impact 5
Cite this article 5
Title page 6
Article Title 6
Author information 6
Abstract 6
Article content 7

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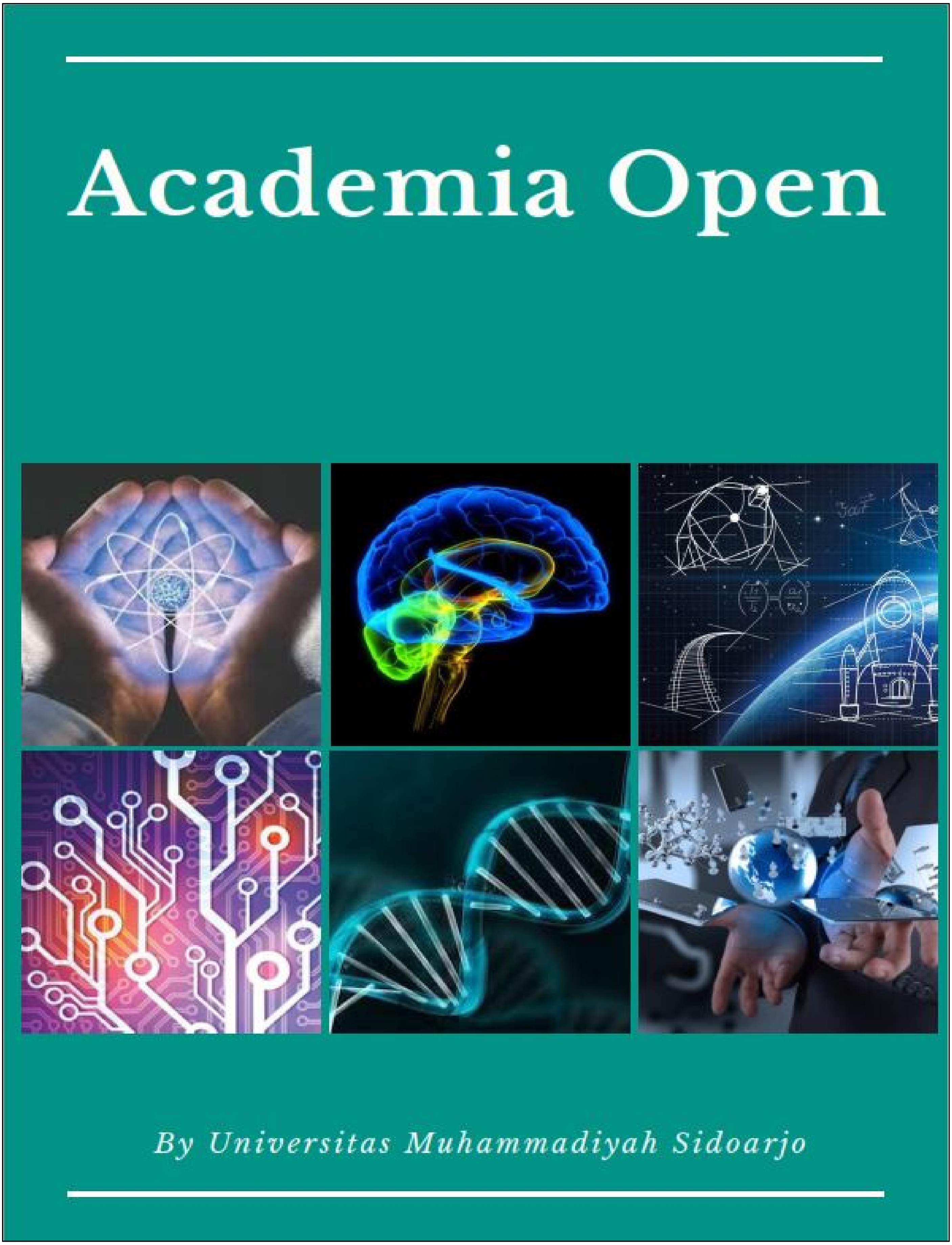

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Assessment of Possible Road Injuries Caused by an Earthquake

Penilaian Kemungkinan Cedera di Jalan yang Disebabkan oleh Gempa Bumi

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Abstract

The article provides data on the extent to which the forecast of the state of roads in a region with a strong earthquake, the level of damage of vehicles during an earthquake depends on their physical state of absorption due to atmospheric, hydrosphere, lithospheric effects and man-made impacts and to what extent special requirements for the construction and control of transport facilities in seismic areas are met, as well. The assessment of the destruction of roads that may occur as a result of an earthquake provides for such aspects as the conclusions of the control of transport facilities carried out earlier in seismic areas, the identified causes of road damage, the effectiveness of antiseismic protection methods when carrying out new construction work and the overhaul (reconstruction) of transport infrastructure to increase seismic stability. The degree of damage to vehicles due to an earthquake is divided into five parts according to the set "rules of transport facilities in seismic areas" (d1–d5), the characteristic of damage situations in each and, accordingly, the degree of damage to structures is shown in the table. From the cited data, on the example of the Angren-Pop railway line, certain levels of damage are observed at high scores of earthquake intensity, even in seismically stable structures, and measures to eliminate damage according to construction standards are covered.

Highlights:

1. Road and vehicle damage linked to seismic and environmental factors.
2. Assessment of antiseismic methods and transport facility standards.
3. Angren-Pop railway damage highlights intensity and reconstruction measures.

Keywords: earthquake, transport, artificial structures, road infrastructure, tectonic displacement, seismic area, seismic stability, tectonic wave, seismogravitational impact, economic damage, secondary consequence, accident-rescue

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Introduction

Due to earthquakes, the countries of the world suffer a huge social and economic loss. Roads are damaged by landslides and kisses in the mountains, and automobile and rail traffic stagnates, resulting in the disaster area being cut off from the rest of the country for several days.

Forecasting the condition of roads in an area with a strong earthquake is necessary to determine the terrain in the area where the accident occurred, the surface part of the road (road cover), artificial structures (bridges, underground roads, support walls, watercarrying pipes, transport buildings, communication network support poles, etc.), the available forces and means that help to restore traffic, taking Information on the tracks barrier is also considered necessary to make temporary changes to train and car traffic patterns.

In this case, the assessment of the damaged road will also apply to the top layer of the Earth, the surface layer of the road, road covers, protective equipment, artificial structures, buildings, other objects that are aligned with the road infrastructure and are located on the roadside.

The rail, highway, and urban road management service operationally evaluates the state of the transport facilities of remote and remote districts to plan urgent repairs and restorations that allow traffic traffic in the area where the disaster occurred in the event of a natural disaster, as well as temporary changes to the train and car traffic patterns of the area where the earthquake occurred.

The level of damage of vehicles during an earthquake will depend on the state of physical absorption due to the effects of the atmosphere, hydrosphere, lithospheres and man-made influences, aswell as to what extent special requirements for the construction and control of transport facilities in seismic areas are met. As such, road damage rates are assessed as being seismically unsustainable compared to structures, with low seismic stability, and at a seismically stable level.

The strength of an earthquake is estimated on the basis of the influence of the natural environment, Technosphere, biosphere and anthropospheres on the overall impact of damage factors of tectonic shifts that cause the rupture of the Earth's crust.

There are many examples of damage to engineering structures due to earthquake-induced kissing, sliding, flooding, landslides, subsidence of the ground layer, as well as the secondary effects of seismogravitational impacts [1-10].

In combination with the influence of tectonic waves, the transport infrastructure is damaged or destroyed due to the occurrence of secondary damaging factors of the earthquake. The destruction of traffic content caused by damage to the stability of the work system, which ensures the safe service of structures and roads, can turn into man-made disasters such as fires, pollution of the environment with harmful substances being carried away from the road. Therefore, when designing new objects, strengthening existing structures and restoring objects after destructive vibrations, the above situation should be taken into account [11].

Ground tremors in the crash area can recur for a long time (from several days to several months) with additional damage to the structures.

To ensure traffic safety, the road control service must constantly monitor the transport infrastructure in the area where the earthquake occurred during seismic activity, including in the case of a 6-point aftershock on the MSK-64 scale [12].

When assessing the destruction of roads that may be caused by an earthquake, it is necessary to provide for such aspects as the conclusions of the control of transport facilities carried out earlier in seismic areas, the identified causes of road damage, the effectiveness of antiseismic protection methods when conducting new construction work and the overhaul (reconstruction) of transport infrastructure to increase seismic stability.

The destruction of the bridge occurs in a state of seismic intolerance under earthquake conditions of magnitude 9-10.

It is recommended to assess the extent of road damage as seismically unsustainable compared to structures, low seismic stability, and seismically stable.

The category of seismically unstable structures can be strengthened by their overhaul (reconstruction). Overhaul, composition and performance of seismic events are determined taking into account the conclusions and recommendations of engineering and seismic studies, inspection, testing and calculation data on seismic stability of structures.

Structures that are seismically stable must comply with the guidelines of the document governing the study and design of transport structures in seismic areas, as well as have a corrected technical condition.

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When developing an overhaul and reconstruction mud shed for structures that are not seismically stable and have a low level of stability, it would be correct to take into account antiseismic activities that correspond to the existing requirements for mudflats in seismic areas [11].

Antiseismic activities carried out in the process of construction, overhaul and reconstruction of structures that are not seismically stable when assessing the possible damage conditions caused by an earthquake, do not guarantee that these structures will remain undamaged in the event of an earthquake with a force higher than the earthquake Force taken into account.

When planning restoration work in the area where the accident occurred, it should be assumed that in order to reduce the sanitary and catastrophic losses of the population, it is necessary to restore transport facilities under the temporary scheme within the maximum reduced period [13-17].

Earthquake power and road damage forecasting data are used in planning traffic recovery works in the area where the accident occurred, in introducing a temporary limit on weight and speed on vehicles to ensure traffic safety and carry out facilities recovery work at a short opportunity [18, 19].

Repair and restoration work on roads is carried out with the aim of restoring vehicle traffic on road networks in areas affected by the earthquake. The composition and scope of the work is determined depending on the requirements for the safety of movement in the areas under restoration.

Repair-restoration work includes restoration of damaged road signs, replacement of damaged rails, repair of hard covers on highways, cleaning of the road part from fragments of fallen rock from the side of the road, restoring the initial condition of bridge spans, strengthening damaged columns and communication networks, restoring the passenger platform, replacing electrical equipment of power supply substations and other work.

Methods

The possible loopholes on the roads are estimated by determining the strength of the earthquake on the basis of the MSK-64 scale, taking into account the likelihood of tectonic cracks on the surface of the Earth and the engineer-geological conditions of the area.

In accordance with the set " rules of transport facilities in seismic regions", the engineering of which can cause the calculated seismic impact (assessment of seismic stability) in the design of transport construction objects is determined on the basis of seismic risk (the probability of an increase in the calculated seismic strain in an interval of 50 years), that is, it is The degree of damage to vehicles due to an earthquake is divided into five parts according to this set of rules:

□□1 – rock heap deposition and rock precipitation in mountainous areas, in which sand, large sand, gravel and large pieces of Rock spilled from the mountainside block the highways and rail tracks, making it difficult to operate the roads in accordance with;

□□2-creates the precipitation of the soil layer over bridge roads and water-carrying pipes and the tilting of the pillars of the communication network, a condition that blocks the movement of vehicles. In the mountains, separate stones fall from the side walls of the gorges into the highway (railway) and give rise to kisses in hajm, which are more than a few hundred cubic meters;

□□3-in flat areas of the territory, the slope of the rail rails is observed in cases of cracks in the ground layer. On the tracks leading to the bridge, the lift is 50 cm relative to the moving part of the cone. There are kisses and displacements on the slopes near the railway tracks and highways, where the size reaches several thousand cubic meters. Due to soil thinning, landslides and the occurrence of mudflows, there is a destruction of the road area, which is built from bases that are not well saturated with water;

In average engineering conditions on planar plots, the earthquake force I, points	Degree of damage to structures		
	Seismic unsustainable structures	Structures with low seismic stability	Seismic stable structures
6	□□1	□□0	□□0
7	□□2	□□1	□□0
8	□□3	□□2	□□1
9	□□4	□□3	□□2
10	□□5	□□4	□□3

Table 1. *The degree of damage due to the strength of the earthquake*

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□□4 -The limit of deep cracks in shallow grunt heaps aligned along the 4th Road axis is caused by an increase in the movement part of the road to 1.0 meters and a decrease in the lift cone lying on the shallow grunt to 1.0 meters vertically, sliding relative to the movement part on the roads leading to the bridges. From the main area of the earth canvas at the top of the steep slope, a railway rail sleeper fence is thrown;

□□5 – there is a complete destruction of the Earth's layer as a result of gravity waves caused by kissing, flooding and muddy flows, as well as rockfalls from the Highlands to lakes and reservoirs. The occurrence of tectonic pits at the intersection of seismotectonic faults in the mountain ranges results in cases of road flooding.

The extent of damage to vehicles at d1–d5 due to the earthquake is measured by an isoseist area of 6 to 10 points. The extent of damage caused by earthquake force is shown in Table 1.

Probability of the degree of damage to buildings and structures and types of elimination P.P. It is analyzed based on the following tables, which Vasiliev presented.

Degree of injury	Earthquake intensity, J							
	5	6	7	8	9	10	11	12
0	100	90	40	4	0	0	0	0
1	0	10	50	36	4	0	0	0
2	0	0	10	50	36	4	0	0
3	0	0	0	10	50	36	4	0
4	0	0	0	0	10	50	36	4
5	0	0	0	0	0	10	60	96

Table 2. *The possibility of various degrees of damage to building-structures of Type V as a result of an earthquake [20]*

Building and structure type	Description of buildings-structures of the same type
A	Rural structures raised from stone slabs, raw brick and Pax
Б	Structures with baked brick, large balconies, tightly built of natural stones
B	Panel, monolithic type, reinforced concrete frame construction structures

Table 3. *Building-structure Category [20]*

Degree of injury	The likelihood of injuries at this level	Number of damaged structures at the level shown	Measure to eliminate injuries according to building standards
0	0	0	
1	0,04	48	Current repair
2	0,36	432	Intermediate repair
3	0,50	600	Capital repair
4	0,10	120	Facility demolition required
5	0	0	

Table 4. *Damage assessment of building structures after earthquake [20]*

Result and Discussion

Based on the research carried out, it will be known that damage in seismically unstable structures will be observed from 6 points, seismic stability will be observed from 7 points in low-rise structures and seismic stability will be observed from 8 points. The małkmki Angren-Pop railway line passed through a seismic active area of 8-9 points. From the above information it can be seen that even in seismically stable structures on this railway line, certain degrees of damage can be observed at high scores of earthquake strength.

If the category of building-structures on the Angren-Pop railway line is considered to belong to Type V (Table 2), the probability of their damage according to Table 2 at different intensity of an earthquake on the MSK-64 scale:

In 8 points, level 0 is 4%, Level 1 is 36%, Level 2 is 50%, level 3 is 10%,;

In 9 points, level 1 is 4%, Level 2 is 36%, Level 3 is 50%, level 4 is 10%.

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Conclusion

Based on the above considerations, we conclude as follows. That is, according to Table 4, the level 2 damage of buildings and structures will be higher than 36%. In this case, it causes average repair of buildings and structures. If the level 3 damage is 50%, the building and structures will need major repairs. It is worth noting that in our example, the level 4 damage of structures in a 9-point earthquake is 10%. Because in the case of damage of the 4th level, it is necessary to demolish and restore the structure. If such damage is observed on roads, it is different from buildings. Railroad tracks on the roads require repair at level 5 damage. There is almost no need for repair in 1st and 4th degree damage.

It is assumed that according to schedule 4, Level 2 damage to buildings-structures is greater than 36%, and Level 3 damage is 50%, which will require overhaul. In our example, it is worth noting that level 4 damage to structures in a 9-magnitude earthquake is 10%. Such damage requires demolition and restoration of the structure

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