Technical preparation solutions of construction land to prevent landslides and flooding in Da Lat urban planning

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Abstract

In recent years, under the impact of the increasing rate of urbanization and prolonged heavy rain due to the effects of climate change, urban areas in the highlands of Vietnam in general, and Da Lat City, in particular, have faced a lot of significant consequences due to landslides and local flooding. Fromthe perspective of urban planning and with the view that urban planning solutions are considered a source solution in preventing landslides and flooding, the following article presents a general understanding of the technical preparation of urban construction land, the current situation of landslides and local flooding in Da Lat city and based on that, propose planning solutions to preventing landslides and flooding.

Key words: *planning, technical preparation solutions, landslides, flooding, Da Lat*

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I. Question

Located in the south of the Central Highlands region, Da Lat is rarely affected by destructive natural disasters such as storms, super storms, and earthquakes, but typical types of regional ones likes drought, heavy rain, local flooding, floods, flash floods, landslides, natural forest fires, etc. Mountain terrain distributed in Da Lat City has a slope of over 15 degrees, which is strongly divided, most rivers and streams have quite small basins with many rapids and at the same time, waterfalls are upstream, which is often affected by flash floods and landslides. The residential area is concentrated mostly on high-altitude areas, mostly following topography with relatively gentle and flat slopes. The biggest impact of this area is the massive amount of water running on slopes within a short time in heavy rain. It reduces flooding and landslides. Due to the short water concentration time, flooding and landslides were created from the mountains and hills. Faced with the above situation, researching and proposing technical infrastructure solutions in general and technical preparation solutions in particular for adapting to climate change and suit the natural situations of Da Lat as well asforpreventing landslides and local flooding in the city is very urgent.

II. Content

1. Technical preparation work for construction land in urban planning

Technical preparation for urban construction land is based on natural situations to synthesize, analyze, and determine the favorable level of land for construction and propose technical improvement measures, which will improve unfavorable situations to satisfy the requirements of urban construction planning [1].The main measures of technical preparation for urban construction land include:

- Ground elevation planning: reorganize the surface of natural terrain to create a design surface for works and urban land.

- Surface water drainage: organize the drainage of water running on the surface of the construction land including rainwater, water for watering plants, watering roads, and water from melting snow (of which rainwater is the main one).

- Lowering the underground water level: increase the depth of the underground water level to minimize the impact on construction and the project.

- Protect construction land from flooding: ensuring urban safety against the threat of natural phenomena such as floods, rising water...

- Other special technical preparation measures include preventing and combating landslides, ditch erosion, underground cavities, mud and rock flows, as well as earthquakes.

Thus, it can be seen that technical preparation for urban construction land is a broad field related to many different specialties used in the preparation of urban planning projects. It can also be called technical preparation planning.

Technical preparation planning is understood as the study, assessment of land funds, and proposal of technical preparation measures for the construction of land in a planning project. In particular, researching and proposing measures for ground elevation planning and drainage planning are mandatory with a large proportion of work.

The purpose of technical preparation is to improve natural conditions and create the best living environment. To use the land area for effective urban construction planning purposes, it is necessary to evaluate its potential. The results of natural condition assessment are one of the important bases for selecting construction land, determining the functional structure of the urban

Figure 1. Slope collapse at alley 36 Hoang HoaTham, Da Lat City on June 29, 2023 [2]

Figure 2. A typical flooded location in Da Lat City during the rain on September 1, 2022 [2]

area, and orienting construction technical solutions. Orienting the development of urban space in accordance with natural situations will minimize the impact on nature, preserve the value of the natural landscape, ensure environmental ecological requirements, and be an opportunity as a basis for sustainable development. In addition, technical preparation measures also play a role in ensuring safety for urban operations, contributing to increasing aesthetic value in architectural space, together with creating favorable technical situations. for the construction of infrastructure as well as works in urban areas, bringing high economic efficiency in the exploitation and use of construction land funds.

2. Current situation,the causes of landslides, local flooding in Da Lat City,and lessons learned

The planning situation of Vietnam's hilly urban areas, especially in Dalat City, shows that the favorable characteristics of terrain factors have also been exploited through reasonable solutions in choosing construction land, model orientation and spatial development direction, and urban technical infrastructure development orientation. The disadvantages of the terrain are also oriented to be improved to create a future surface to meet urban development requirements. However, there are still many inadequacies related to the selection of urban planning solutions that are not suitable for the terrain or construction management that has not been strictly followed according to planning orientations, leading to issues like waterlogging, inundation, landslides, landscape disruption, ecological imbalance, reduced long-term economic efficiency, failure to create local identity...

a. The current situation of local landslides and flooding

As a city in the Central Highlands region, landslides most often occur on pass roads and in Dran town (Don Duong district), Da Lat City. In the first months of 2023, due to heavy rainfall and prolonged periods of rain, the ground is weak, causing several very serious landslides, specifically:

June 17, 2023: 02 landslides occurred in Da Lat City, killing 02 people; June 29, 2023: 13 landslides occurred in Da Lat City, killing 2 people and injuring 3 people; 02 solid houses collapsed, 01 solid house was seriously damaged, 09 houses were partially damaged, 01 electric pole was broken; 13 pine trees fell. The damage was huge after the rain from the night of June 28 to the early morning of June 29, 2023, with up to 200mm of rain causing landslides, flooding in many places, and serious slope collapse in alley 36 Hoang HoaTham, Ward 10, killing 02 people, injuring 05 people, affecting many people's houses.

Through the review, 163 current locations with landslides and at risk of landslides throughout Lam Dong area, Da Lat City accounts for more than 1/3 of the above number with 60 locations. (Source: Department of Agriculture and Rural Development of Lam Dong province).

In recent years, extreme weather, the number of concentrated heavy rains, and urban flooding are showing signs of increasing. In Da Lat City, flooding mainly occurs along the Cam Ly stream basin intersecting with Phan Dinh Phung Street to Mac Dinh Chi residential area and around the Xuan Huong settling lakes.

At the beginning of the rainy season in 2023, many heavy rains caused serious damage. On June 23, 2023, after a rain of over 60mm during 1 hour and 30 minutes, many roads (Phan Dinh Phung, To Ngoc Van, Tran Quoc Toan Street,...) were deeply floodedand trees were uprooted. The damage was actuallyenormous aftera long rain of 200mm fromthe night of June 28 to the morning of June 29, 2023, causinglandslides and flooding in the whole city. On the afternoon of July 17, 2023,all areas where flooding often occurs were flooded all over after the 90mm of rain.

Through the review, Lam Dong currently has 73 locations at risk of flooding and Da Lat City has 12 places that appeared in heavy rains. (Source: Department of Agriculture and Rural Development of Lam Dong province).

b. Cause of landslides and local flooding

The causes of the above situations have been notcarefully analyzed in evaluating the actual situation. In addition, construction activities according to the enacted planning are not well implemented. The quality of urban planning projects is not high and the solution is still subjective without inter-sectoral coordination. Moreover, design solutions, especially in terms of technical preparation, are still quite general.

Landslides and flooding in recent times come from objective and subjective causes, including:

Objective reasons:

Effects of climate change:the rainy season in Da Lat lasts from May to November, mainly in June and July (June 2023 alone will reach 349mm with an increase of 54% and July will reach 442mm with an increase of 36% over the same period in 2022); At some times, the rainfall in Da Lat City is very high, from 100mm-190mm/day, which will weaken the ground, cause landslides, and the amount of water suddenly rushes into drainage basins, making the existing system of canals, ditches, and streams overloaded and unable to

Figure 3. Streams and regulating lakes in Da Lat have been encroached on and sedimented, reducing the water storage space of Da Lat [3]

ensure the drainage function.

Terrain characteristics: the terrain is mainly mountainous, with altitudes from 200m-1500m above sea level. Soil groups are mainly composed of red basalt soil, alluvial soil, etc land with high slopes (above 25 degrees, accounting for 50%), the soil structure is weak, causing a very high risk of landslides in prolonged heavy rain.

Geological characteristics: the geological foundation is poorly connected, with mainly unconsolidated basalt, soin prolonged heavy rain, water in the soil is saturated, leading to landslides, slides, and cracks. In addition, due to geological architecture and stratigraphy creating heterogeneous geological structures, sliding arcs have a large scale and degree of influence.

Subjective reasons:

Construction activities: leveling and excavating activities to create ground for construction works in locations, which have steep slopes, high negative/positive slopes, and are at risk of landslides. The quality management (design, construction, supervision) of the entities involved in construction (investors, construction units, consultants, etc.) is not fully guaranteed according to regulations.

State management: localities have not promptly reviewed all areas at risk of landslides, especially steep hills and areas with high negative/positive slopes to strengthen quality management, survey, design, and appraisal before and after granting construction permits; Planning and changing land use purposes in steep, rugged mountainous areas was proceeded. Organizing and implementing the planning is still slow and ineffective. Most urban planning projects identified basins and oriented drainage routes, but the implementation of drainage systems according to planning is still slow. The basic system of canals, ditches, and streams, has just been reinforced according to the current status but does not meet and match the requirements and speed of urban development. The maintenance and repair of the drainage system are not effective; Dredging sludge from rivers, canals, and the network still has many limitations; Flood discharge operations at small regulation lakes have not been paid attention to; Funding for these activities is still quite modest. The capital source for new construction, renovation, and upgrading of urban drainage systems is huge and needs to be invested synchronously; However, reality shows that capital resources are very limited and mainly rely on the state budget. Poor coordination between investment in the construction of technical infrastructure and drainage works is also the reasonfor greater complexity in solving drainage problems.

Drainage capacity of the drainage system:

Drainage systems are mostly built on old urban foundations (which are incomplete and have many limitations). Most of the sewer network was built a long time ago and has only concentrated in old residential areas. The size of the holes is small, the distance is large and they are still blocked by garbage, therefore, if itrains heavily, water cannot be drained promptly and, cause flooding. Many road and alley systems are hardened but lack a drainage ditch system, preventing water from flowing along the road surface, draining freely and uncontrolled. Besides, the repair and improvement of roads and sewers in some places do not meet the requirements, such as the sewer system on Hoang Dieu Street, and Hai Ba TrungStreet near the Hoang Dieu Hai Thuong intersection, etc are all quite small and narrow. In many new urban areas, the construction of drainage systems is not synchronous and the connection between the new drainage system and the old one still has many shortcomings; On the other hand, connecting the urban drainage system with the irrigation system has still many limitations. When heavy rain happens, some low-lying areas often become stagnant and flooded for long periods, making it difficult for residents to daily activities.

In addition, the state of sedimentation and encroachment on the corridors of regulating lakes, canals, and streams by encroaching housing construction and greenhouses changes the flow, and the lakes gradually lose their regulating ability to reduce water flow. Water flow is concentrated during heavy rain while the drainage system is narrowed,which is unableto ensure itsdrainage capacity. Da Lat City is divided into 3 basins, most of which do not have their rainwater drainage system, therefore, rainwater flows only drain into rivers, streams, and lakes through the natural terrain. However, due to sedimentation and encroachment, the lakes gradually lose their regulatory ability.

Status of concrete and development of net houses and greenhouses:

Currently, the pace of urbanization is increasing rapidly, accompanied by increased construction density. Areas where construction is allowed are covered with concrete by construction projects; Agricultural land areas, even forest land, are covered with net houses and greenhouses (according to statistics, in Lam Dong province there are currently 4,500 hectares of greenhouses, of which the largest number is in Da Lat, with about 2,800 hectares, accounting for more than 62%). It narrows the water space and land, reduces the ability of absorbingwater into the soil, and makesmany new great-intensity flows without control. Not only does stagnant water cause flooding, but it can also easily induce landslides, threatening people's lives and property.

Planning and urban development management:

In practice, the vision of urban development planning and management is still limited, which are also direct or indirect causes of urban flooding such as:

Drainage system planning according to regulations is not prepared separately from provincial planning, regional planning, and urban planning projects. Therefore, it lacks specificity, and regional connection and there are still some subjective factors; Forecasting has not fully anticipated

Figure 4. A greenhouse agricultural area in Da Lat City [2]

climate change and the development of net houses and greenhouses, so the planning design parameters are no longer consistent with the actual situation, making some drainage routes to become unsuitable and overloaded, etc.

Lack of synchronization in land use planning and construction planning leads to the separation of plots, forming residential areas lacking infrastructure, and the drainage system requirements are not guaranteed, not by the planning orientation. Changing land use purposes and building structures in low-lying areas with regulating functions or locations that obstruct flow are also causes of local flooding.

Awareness of the community:

Residents have not got enough awareness to keep their living environment. They still construct houses and works without complying with construction regulations, leveling and encroaching on water areas such as rivers, canals, ponds, and lakes; exploitingexcessively groundwater; and Indiscriminately dumpingwaste into manholes, canals, sewers, and onto roads leading to blockage of drainage pipes and making drainage even more difficult.

c. Lessons learned on preventing and controlling landslides and local flooding

Canberra City (Australia)

Canberra City is a completely new city built to become the capital of Australia in the early 20th century. This area is a highland terrain that is not only convenient for construction but also has beautiful scenery. The city center has a similar topography to Da Lat City. The city's architectural space is formed on the basis ofconnecting urban space with topographic and water surface elements, in which Burley Griffin artificial lake plays a particularly important role.In addition to blocking the flow to form lakes and wetlands, topographic components are fully utilized in urban planning. The hills are planned for residential units with an internal road network curving according to the terrain; valleys are for green areas. The organization of surface water drainage follows Sullivans Creek and drainage channels. Along the directing routes, there are wetlands holding water, which is to reduce the flow volume pouring downstream. The channel section is reinforced with a sloping roof and there are overflow corridors on both sides.

Typical lessons on landslide prevention from Japan

Currently, many developed countries around the world have researched and applied many effective solutions to cope with flooding and landslides, including Japan. Landslide is a combination of many factors such as terrain, geology, stratigraphic structure, rainfall, and human factors, so soil hazard response measures are also different. In general, these measures can be classified into control solutions and prevention ones.

The Japanese have used control solutions including water collection like well constructions, in which groundwater in the landslide area is collected and drained by digging underground wells with water collection drill pipes or placing horizontal drill pipes, in which groundwater is collected and drained by drill pipes placed horizontally on the surface. Prevention solutions include anchor-reinforced constructions and deep foundation piling ones.

Planning solutions contribute to preventing landslides and flooding

Urban planning practice has shown that the role of topographic factors, as well as urban planning solutions suitable to the terrain and the role of technical preparation of construction land, is vital to create an artificial environment in harmony with the natural environment in urban planning. Therefore, there needs to be directional solutions in Da Lat urban planning from the perspective of reasonable exploitation of topographic factors based on the requirements for urban space development. These will also be effective solutionsin overcoming urban landslides and flooding that have caused significant consequences in recent times in Da Lat. The principle solutions below are proposed for use in urban planning projects in Da Lat to contribute to preventing landslides and flooding.

Assess the natural situations of the land

Assessing natural conditions of the construction land in the corner of technical preparation is understood as evaluating the technically favorable level of technical construction on the land. The natural elements need to be evaluated including climate and terrain, hydrology, engineering geology, and hydrogeology... The aim is to possibly exploit and effectively use land both for the environment and expense.

Assessment of natural situations of the land is conducted at the stage of master planning with the tasksrelated to classifying and determing the areas which are favorable, less favorable, and unfavorable for construction. These are the basis for selecting suitable landfor construction, functional subdivision, and proposing technical preparation measures.

For urban areas characterized by wavy hills alternating with valleys like in Da Lat, analyzing and evaluating natural terrain factors is an important task and needs to be considered in both aspects: construction and landscape engineering.

Technically, it is necessary to evaluate the favorable

Figure 5. The spatial organization closely follows the natural terrain, making the most of drainage condensations in Canberra City [8]

level of natural terrain conditions (mainly slope) for urban construction based on land classification regulations: (1) favorable Land for construction (slope from 0,4 to 10%); (2) less favorable Land for construction (slope from 10 to 20%, mountainous areas up to 30%); unfavorable Land for construction (slope > 20%, mountainous area > 30%).In addition, areas with separate sliding soil terraces that can be simply treated will be assessed as less favorable soil; Areas with many consecutive sliding terraces that require complex treatment will be considered unfavorable land for construction. The construction land assessment map for Da Lat City needs to be integrated with the risk zoning map and landslide risk warning in the study area based on survey, analysis, and forecast results.

Regarding landscape, it is necessary to analyze and evaluate the landscape characteristics and potential of a land area, including Characteristics of the land's appearance (flat terrain, evenly sloping terrain, divided terrain...); Limit the division of terrain by distributaries and reservoirs; High points, low points, views and directions, obstacles of natural terrain; The influence of terrain on the ability to observe and perceive space...

Exploit and use terrain

Reasonable and effective exploitation and use of terrain are one of the leading principles in Da Lat's urban planning and design. It contributes to creating an urban space in harmony with natural features, maximizing the potential and limiting the disadvantages of the land. At the same time, it contributes to protecting the environmental landscape, preserving valuable landscapes, and developing high-quality and sustainable Da Lat urban.

Topographic factors need to be considered in functional zoning; selecting the location of works as architecturalhighlights; determining the spatial axis; organizing the road network; arranging the layout of architectural works; determining construction density and building height; dividing construction phases, etc.

Figure 6. Planning diagram of solutions to prevent rock falls, landslides, and flash floods in Japan [4]

Based on the results of the analysis and assessment of the terrain, the level of exploitation and use of the terrain is also different depending on construction requirements and terrain characteristics. For example: In cases where the terrain has a unique surface structure, it will be retained in the urban landscape, as a nature reserve, green area, or forest park; Utilizethe advantages of low-lying areas to create water landscape elements;

Buildings should gradually reduce their height and construction density when approaching water or valleys; Taking advantage of terrain elevation to arrange landmark buildings; Arrange buildings parallel to the contour line along the length of the structure.

The overall site planning plan is established on the basis of exploiting and using the terrain of the land, which will bring compatibility and harmony with the natural situations and typical ecological environment of Da Lat, thereby minimizing the impact of destroying natural structures which/that has been recently replaced by new construction sites.

Ground elevation planning of construction land (ground elevation planning)

Research and design of ground elevation planning for construction land in Da Lat urban area needs to comply with principles, the most important of which is the principle of thoroughly taking advantage of natural terrain. We must try to maximize the use of the good aspects of natural situations, take advantage of the existing terrain, and retain green areas and fertile soil layers to bring about high efficiency in landscape architecture and economy. Leveling should only be done in areas where construction works, streets, and yards are located, and in other areas. If it is possible, we should keep the terrain intact situations, especially paying attention to ensure all leveling activities do not narrow the flow.

Figure 7. Land assessment according to natural terrain factors in Da Lat urban planning area and surrounding areas

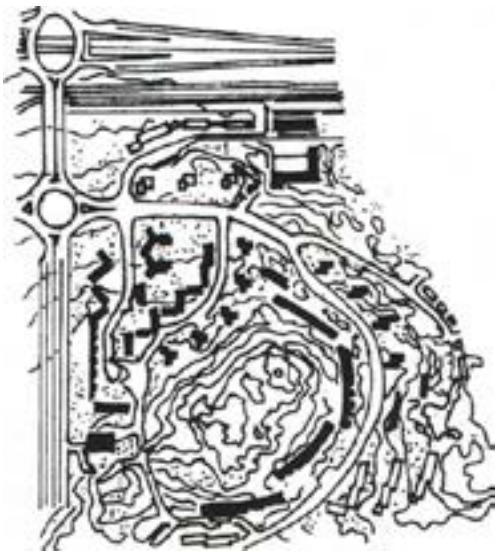

Figure 8. Master plan suitable for natural situations [6]

Organize surface water drainage

The design and planning of surface water drainage systems are closely linked to the planning of the ground elevation of the land. It is necessary to take full advantage of the terrain to design a free-flowing drainage network and make full use of streams, lakes, and low-lying areas. Low water can be drained or used as a regulating lake.

For the highland terrain in general and Da Lat urban area in particular,special attention should be paid to analyzing the characteristics of hill terrain and hydrological conditions of flow concentration to organize surface water drainage runs to, natural flows such as streams, and water reservoirs. In planning the surface drainage network, the drainage flow not only needs to be calculated for the sewer lines along the road but also needs to calculate the concentrated flow according to the drainage joints, thereby determining the

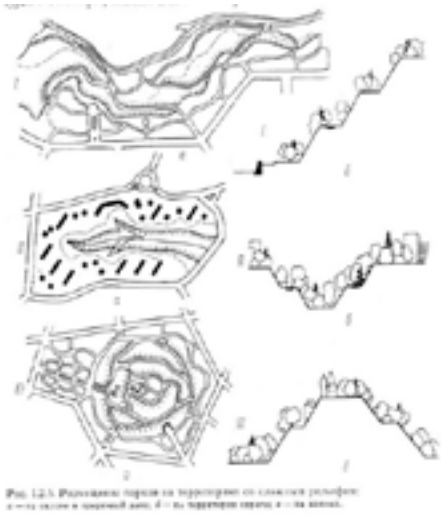

Figure 9. Location of land in complex terrain [7]

a. Located in the riverside area
b. On ravine territory (constructions built on rolling hills using valleys for drainage)
c. On the hill

Figure 10. Analysis of topography and flow in Da Lat City

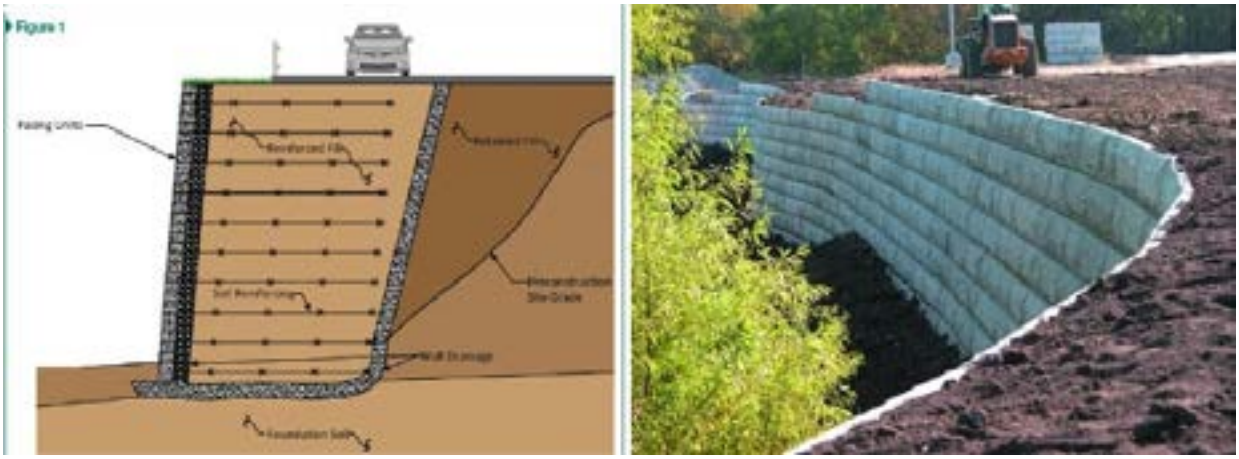

Figure 11. Structure of geotextile retaining wall [2]

required flow cross-section, the necessary size of bridge and culvert across the road and safety corridors along the flows to ensure water drainagein the case of unexpected heavy rain. The hydrological calculation to determine the flow rate must also take into account the impacts of climate change in proposed scenarios, which makes changes in calculating rainfall. Besides, there is also a need for more specific calculations on the flow coefficient, which has changed a lot under the impact of urbanization and greenhouse agriculture.

Technical measures for construction land with landslides

For landslides, natural terrain (topography, slope) and impacts of terrain improvement are factors contributing to landslides. Urban planning solutions in general and technical preparation in particular need to limit impacts that cause imbalance and natural stability of the land.

Measures to prevent and control landslides that can be applied appropriately in construction planning for Da Lat urban area are:

- Ground elevation planning: leveling to create a ground according to appropriate levels and slopes, pre-loading the low part, replacing soil on sliding surfaces; Avoid digging and cutting the foot of the slope and limit construction or loading on the slope on the basis ofplanning the site in accordance with terrain characteristics.

- Organize surface water drainage: regulate surface flow on land areas and slopes to limit water seeping deep into the ground at risk of landslides and at the same time have measures to collect and drain underground water from within the land. hydrate to reduce water pressure and increase soil strength.

- Plant trees to prevent erosion and weathering on slopes, paying special attention to planning for the conservation and development of pine forests not only as a typical landscape element of Da Lat but also contribute to stabilizing sloping land areas.

- Lower the slope to increase slope stability, reduce sliding force, and increase sliding resistance. Changing the shape of the slope must be in harmony with the landscape and typical ecological environment of Da Lat City.

- Reinforce and stabilize the slope using technical measures such as Covering nets, ground spraying, soil anchors, soil nails, retaining piles, gravity walls, and geotechnical retaining walls... priority should be given to solutions applying advanced technology to handle landslides sustainably, limiting construction. Soil retaining walls made of large stones or concrete disrupt the landscape.

III. Conclusions

Analyzing and evaluating topographic and hydrological situations will be the basis for choosing architectural space layout solutions, along with determining construction density appropriate to natural situations, thereby minimizing the impact as well as harmonizingwith nature during the urban construction process. Solutions for planning ground elevation and organizing surface water drainage thoroughly take advantage of terrain shape; Technical measures to prevent slippage, used properly, will contribute to overcoming landslides and flooding in Da Lat City.

To meet the goal of developing Da Lat into a unique urban area in terms of planning, architecture, natural landscape, and sustainable development, technical preparation solutions need to be determined at all stages of urban planning as well as ensure harmony with natural situations, and the stability,together with balance of the natural structure./.

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