MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF CONSTRUCTION

HANOI ARCHITECTURAL UNIVERSITY

CHU VAN HOANG

MANAGEMENT OF URBAN GROUND ELEVATION TO REDUCE FLOOD IN THE EXTENDED DEVELOPMENT AREA SOUTH RED RIVER DELTA REGION CENTRAL HANOI

SUMMARY OF DOCTORAL THESIS

SPECIALITY: URBAN AND CONSTRUCTION MANAGEMENT

The thesis was completed at Hanoi Architectural University

Under supervision of:
Associate Professor, Dr. Nguyen Lam Quang

Examiner 1: …….

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This thesis had been defended at the Doctoral Examination Council at Hanoi Architectural University
At ……..a.m/p.m ……..date……month…….year 2021

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INTRODUCTION

*** Research significance**

The expanded development area locates in the south of Hanoi's Red River Delta region includes a series of urban to the east of the 4th Ring Road (Dan Phuong, Hoai Duc, An Khanh, Ha Dong, and Thanh Tri districts). This location has the highest urbanization rate and high population growth rate with the available land fund and urban technical infrastructure system for urban development. The urban infrastructure systems' spatial urban planning management and connectivity ability are required to develop existing and new areas. In particular, planning and management of the urban ground elevation are considered the critical factor for water drainage, reducing flood, and contributing to the spatial planning of a city. Therefore, the thesis ***" Management of urban ground elevation to reduce flood in the extended development area – South Red River Delta region, central Hanoi"*** is necessary and has highly practical meaning.

*** Objectives of the study**

- Analysis and assess the current situation of construction planning, urban ground elevation management, and surface water drainage in the extended development area – South Red River Delta region, central Hanoi.

- Propose solutions for urban elevation management to minimize flooding in the extended development area – South Red River Delta region, central Hanoi.

*** Boundary and Scope of the Research**

- The boundary of the research: the extended development area – South of the Red River Delta region, central Hanoi

- The scope of the research: manage the ground elevation for the extended development area south of the Red River of the central urban area of Hanoi

- Period: to 2030, vision to 2050.

*** Research methodology**

The thesis uses the following fundamental research methods: Investigation, survey, and data collection; Analyze, evaluate and synthesize data; Obtain information; Map overlay; Validate the application; Forecast.

*** Significance of the research**

- *Theoretical implications:* Systematize the theoretical basis for the proposal, appraisal, approval, management of urban elevation and rainwater drainage in the expanded development area.

-*Practical implications:* Contribute to the development of regulation in the management of urban elevations and drainage; Applying solutions for urban elevation management to minimize flooding in the extended area in the south of the Red River - the center of Hanoi.

*** Contributions of the thesis**

- Propose the supplement of regulations on landmarks and management of landmarks according to planning, which related to urban background elevation: (i) Fulfill the information of the landmark on the elevation of the approved planning foundation; (ii) Add boundary in areas next to urban areas and existing residential areas; (iii) Add landmarks to define water flow, retention ponds, areas subject to be flooded, primary drainage system.

Fulfilling technical criteria in urban ground elevation and drainage planning projects, including standards on ground leveling area and

surface coverage coefficient, contributes to improving the quality of construction planning projects and urban elevation management.

- Improve the state management capacity on urban elevation management by improving the management organization, applying GIS in management, and community participation in the study area.

*** List of terms**

Some terms have been used in the thesis: Urban development area, extended development area, road center landmark, red line landmark, the boundary of prohibited construction area, urban ground elevation, urban ground elevation management.

*** Structure of the Thesis**

Besides the Introduction and Conclusion, the thesis consists of three chapters:

Chapter 1: Overview of urban elevation management according to planning in cities globally and Vietnam.

Chapter 2: Scientific basis for urban elevation management to reduce flooding in the extended development area south of central Hanoi's Red River delta region.

Chapter 3: Solutions for urban elevation management to reduce flooding in the extended development area south of the Red River delta region, central Hanoi.

CONTENT

The thesis analyzes and evaluates the implementation basis and tools for urban elevation management in several cities, such as San Diego, Sydney, Beijing, Bangkok, Hue, and Ho Chi Minh City.

1.2. Overview of the urban center of Hanoi and the expanded development area south of the Red River regional

**** Urban center of Hanoi city:*** Inner-city area; urban chain east of ring road 4 (including green belt and green buffer) and urban chain north of Red River. *(Figure 1.4)*

**** Expanded urban development area south of the Red River***: Hoai Duc; Dan Phuong; An Khanh; Ha Dong and Thanh Tri. Interspersed between urban areas are the green belt of the Nhue river and the green buffer. This area is a load reduction area for the inner city. *(Figure 1.5)*

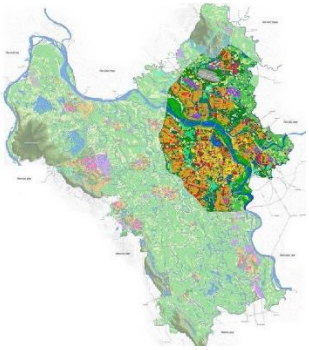

Figure 1.4. Urban location in the center of Hanoi city

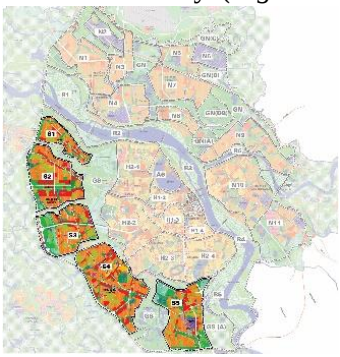

Figure 1.5. Location of the expanded metropolitan development area to the south of the Red River

1.3. Current situation of ground elevation and urban flooding in the center of Hanoi

**** Ground elevation and floods situation in the inner city***: The elevation of the existing buildings ensures that the areas are not

affected by floods. Flooding on a large scale has been basically controlled. However, there are still some local flooding locations. Due to the construction process, the ground level is not well managed, leading to the variation in the ground level between the project area and the existing residential and changing the direction of the drainage flow in the basin.

**** Status of ground elevation and floods in the extended development area south of the Red River***: This location has the highest urbanization rate in Hanoi. Many urban projects have been implemented, but urban ground elevation and stormwater drainage have not been synchronously connected. Variation in ground elevation is quite common. High elevation highways divided the drainage basins, changed flow direction, and caused local flooding in existing residential areas.

**** Current situation of the urban elevation and drainage planning projects in the center of Hanoi:*** The ground elevation and drainage have not been focused on the current construction planning projects. The ground elevation and connection between the project area and existing residential areas have not been identified in the content of the planning projects. The technical infrastructure planning project has not been implemented for urban ground elevation planning. The technical indicators in the urban ground elevation and drainage planning projects have not been established, which causes difficulties for management.

1.4. The current situation of management of ground elevation and surface water drainage according to the planning of the central urban area of Hanoi.

**** Current status of the proposal, appraisal, and approval processes of urban ground elevation and drainage planning projects:*** Making, appraising, approving, and publicizing urban construction planning projects are well implemented. The Department of Planning and Architecture and the Urban Management Department are specialized agencies that advise the authorities at all levels. However, concurrent cadres leading to unprofessional and low-quality assessment, where one person is in charge of evaluating all technical aspects.

**** Situation of urban elevation management and surface water drainage according to planning projects***

+ *Status of construction permits*: Management departments used to provide information of the project elevation based on the height of pavement and road, which lead to difficulties in management and observation.

+ *Level of control of urban drainage and ground elevation*: The Department of Planning and Architecture and the Urban Management Offices of the districts manage the planning of ground elevation and surface water drainage. Department of Construction manages specialized projects for planning elevation of ground level and surface water drainage, construction investment project management, exploitation and operation

+ *Status of the organization*: The Urban Department of the People's Committee of Hanoi; Division of Infrastructure Engineering-Department of Construction; Department of Planning and Architecture; and Division of Urban Management are in charge of infrastructure management. The organization is incomplete and has limitations in exchanging and providing information.

+ *The situation of developing the management database system*: Building the database for management is still limited. The information has not been digitalized and regularly updated, cause difficulties in data management and exporting.

**** Situation of marker and management of boundary markers according to planning***

+ *Situation of setting up landmarks according to planning*: Boundary landmarks placed in the site are used for road center, road boundary, and red boundary lines. Setting up milestones according to the planning has not been completed. Boundary landmarks of drainage systems and retention basin ponds have not been identified, which affect the drainage flow and lead to urban flooding.

+ Current status of landmark management according to approved planning: Regulations of setting, appraising, and approving the boundary markers are incompleted. Information about urban ground elevation according to planning has not been published.

****Community participation in the management of urban elevation***: Community participation is still minimal and ineffective from planning to the implementation stage.

1.5. Literature review

There are no specific studies related to urban elevation management to reduce flooding in the extended development area south of the Red River Delta region, central Hanoi. Existing studies on technical infrastructure systems or stormwater drainage systems are divided into three groups: research on management of urban technical infrastructure, research on management of the drainage system, and analysis on the other related issues.

1.6. Problems need to be solved in the thesis.

- Present overview and goals for urban elevation management to minimize flooding in the extended development area south of the Red River in the central urban area of Hanoi.

- Propose additional content to implement marker planting and management of boundary markers according to the planning related to urban base elevation landmarks.

- Provide technical criteria in the planning project of urban ground elevation and rainwater drainage.

- Propose improvement for the organizational capacity of the state management apparatus for urban elevation management.

- Propose to apply GIS geographic information system in urban elevation management.

- Propose strategies for urban elevation management with community participation.

CHAPTER 2: SCIENTIFIC BASIS FOR URBAN ELEVATION MANAGEMENT TO REDUCE FLOODING IN THE EXTENDED DEVELOPMENT AREA SOUTH RED RIVER CENTRAL HANOI

2.1. Theoretical basis for urban elevation management in the extended development area south Red River central Hanoi.

**** Calculation basis for determining urban ground elevation***: including location topography, flooding situation, flood avoidance method, irrigation and drainage, and ground elevation planning.

**** The relationship between urban ground elevation and flood prevention:*** enhance drainage systems' efficiency based on topography and avoid deep sewage usage. The ground elevation identification and sustainable stormwater drainage planning need to be implemented at once. The reasons are limiting the volume of

earthwork, reducing the concrete surface, and increasing the ground surface's absorbable capability. The irrigation systems should be considered for floods and retention pond control.

**** Principles and contents of ground elevation management in the extended development area south of the Red River central Hanoi.***

- *Basic principles in urban planning and elevation management:* (1) Topography reservation for the city basins; (2) Planting boundary markers in the field according to the approved planning; (3) Comply with current legal documents; (4) New construction, repair, and renovation needs to follow the approved ground elevation; (5) Ground elevation should be provided in when construction permit is issued.

- *Urban background elevation management content*: (1) The urban ground level must meet the requirements for drainage flows and must be approved by local authorities; (2) The authorities responsible for managing and providing information of urban ground elevation to organizations and individuals upon demand; (3) Organizations and individuals must comply with the provided information; (4) Agencies competent to appraise basic designs and issue construction permits are responsible for inspecting and supervising.

- *Urban elevation management and geographic information systems (GIS)*: develop the ground elevation management database, integrate local information with coordinated data for urban governance.

- *Urban ground elevation management and construction landmarks*: (1) Landmark planning should be implemented according to the planning stage; (2) The preparation, appraisal, approval, and implemental of boundary markers in the field must be approved by competent agencies; (3) The People's Committees at all levels decide

on the scale of maps for making boundary marker planting dossiers within their approving competence; (4) The profile of landmarks must provide comprehensive information and related contents.

- *Community participation in urban elevation management*: community participation is the trend in urban planning and management.

2.2. Factors affecting the ground elevation management in the extended development area south of the Red River central Hanoi.

**** Topography condition***: Directly affect the process of choosing urban construction land and solutions for planning infrastructure systems. The road network should be arranged according to the terrain slope. It is possible to arrange parallel, perpendicular, and oblique slopes with contour lines in the complex terrain slopes locations. The length of the building and the slope influence building construction.

**** Social and economic conditions***: Directly affect the planning and management of urban elevation. Economic development, urbanization, and population growth speed increase the demand for housing and urban development. These processes increase the quantity of earthwork and concrete surface while changing the water flows

**** Urban size and characteristics***: The basis for calculating and choosing urban elevation is based on the frequency of calculated water level. The designed frequency depends on the significance of the urban construction land and is determined according to Vietnam Construction Regulation QCVN: 01:2019/BXD

**** Technological conditions***: This is one of the significant factors that affect the efficiency of the solutions while achieving the financial requirements, reducing construction costs, speeding up progress, and working safety.

**** Organization management***: must be specified, specialized, and transitional to improving quality and efficiency in management.

2.3. Legal basis for urban elevation management according to the planning of the extended development area south Red River

**** Legal documents***: including the following documents: Construction Law 2014 prescribed in Articles 12, 45, 46, 47, 48; The Law on Urban Planning prescribed in Articles 37, 56, 57; Decree 11/2013/ND-CP; Decree No. 44/2015/ND-CP, Decree No. 80/2014/ND-CP; Vietnam Construction Regulation QCXDVN 01:2019/BXD; Vietnam Construction Code QCVN 07:2016/BXD.

**** Relevant approved planning projects***: The content of planning for ground elevation and surface water drainage has been oriented and designed in the following projects: General Planning of Hanoi Capital in 2030 with a vision to 2050; Planning of Hanoi drainage system in 2030 and vision to 2050; Subdivision planning projects from S1 to S5.

2.4. National and international experiences in elevation management

**** Vietnamese experiences:*** The thesis obtained the theory of several cities, such as Hai Phong, Vinh, and Can Tho.

**** International experiences***: The thesis has analyzed and adapted the theory of elevation management in some cities in the world, including Osaka – Japan, Singapore – Singapore, and Bangkok - Thailand.

CHAPTER 3: SOLUTIONS FOR URBAN ELEVATION MANAGEMENT TO REDUCE FLOODS IN THE EXTENDED DEVELOPMENT AREA SOUTH RED RIVER CENTRAL HANOI

3.1. Perspectives and goals

**** Management perspective***: (1) Establish technical criteria in planning project for urban ground elevation and surface water drainage; (2) Elevation management must be followed the approved boundary markers, field marker planning and applied for the entire city area; (3) Improve the management capacity; (4) Increase community participation; and (5) Apply advanced science and technology in planning, documenting and construction management.

**** Management goals***: (1) Synchronously manage the urban ground level on the entire city land through a system of landmarks that has been appraised, approved, and implemented. (2) Manage urban elevation and surface water base on economic and technical criteria. (3) Improve the management capacity and efficiency.

3.2. Propose technical solutions for urban elevation management

**** Complete the regulations on planning and managing the boundary markers according to construction planning and urban foundation elevation level.***

- *Complete the regulations on planning boundary markers:* Includes: (1) Additional information of the approved elevation landmark; (2) Add boundary markers in the areas next to existing residential areas; (3) Add boundary markers to define the boundaries of the water surface area, the retention ponds, the area subject to be flooded, and the primary urban drainage axes. Boundary landmarks must provide comprehensive information, including landmark name, landmark center (located with x, y coordinates according to the National coordinate system), and design elevation level according to planning. The structure of the landmark is shown in Figure 3.1.

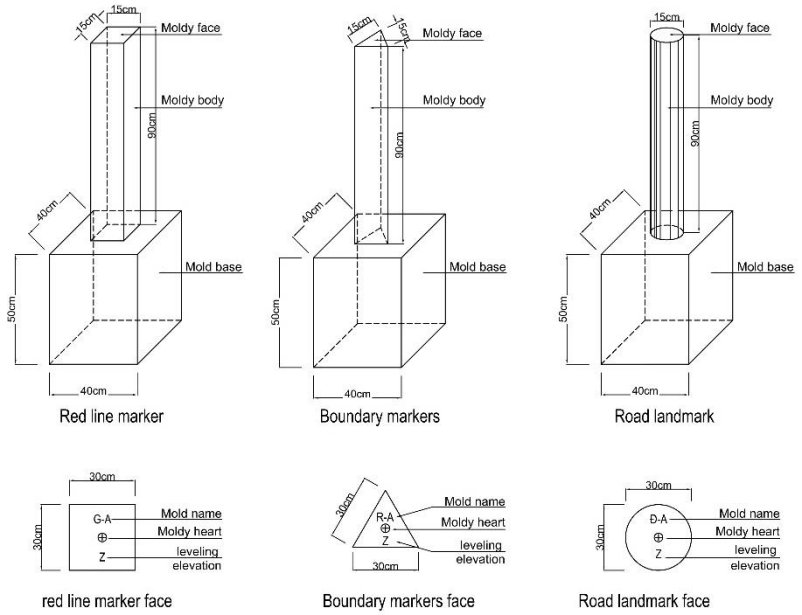

Figure 3.1. Propose structure of landmarks related to urban ground elevation.

• *Propose to manage the urban elevation according to the boundary markers*: provide information on landmarks and propose boundary markers as mentioned above help the authorities handle the boundary marker management according to the planning. Boundary landmarks are the basis for monitoring the elevation in construction activities, ensuring the consistency and synchronization of urban ground elevation, and minimizing local flooding.

**** Propose technical criteria in urban elevation planning project***

According to QCVN 01-2009, it is necessary to determine the technical criteria for the ground elevation and water drainage in the urban construction planning project. These indicators base on economic and technical criteria of land use and city landscape. The following technical criteria should be considered:

• *Propose technical criteria for the urban ground elevation planning project:*

+ Indicators of earthwork:

- For residential, educational, medical, cultural, market, service, and complex functions areas: Leveling criteria bases on construction density %. The maximum allowable leveling area is determined by the formula:

$$S_{sn} = (M_{xd} + a) \times S_{xd} \quad (3.1)$$

In which: M_{xd}: Maximum building density ; S_{sn}: leveling area in the plot; S_{xd}: area of land plot; a: % of the leveled land area increased compared to the construction area according to density. (a) calculated based on the demand for construction of outdoor facilities determined from 0% to 15%.

For public green space: in a non-regularly flooding area, the maximum leveling area and subject to be temporarily flooded should be identified to prevent urban flooding.

- Ground leveling area for public green space:

$$S_{sn} = M_{xd} \times S_{xd} \quad (3.2)$$

In which: S_{sn}: the leveling area in the plot; M_{xd}: Maximum building density ; S_{xd} : the area of the property.

- Area allowed for temporary flooding:

$$S_{ng} = b \times S_{cx} \quad (3.3)$$

In which: S_{ng} : the area allowed to be temporarily flooded; S_{cx}: the total area of green space; b: the percentage of the extent permitted to be temporarily flooded compared to the entire area of green space. b is defined from 0% to 25%

- For technical infrastructure works: The ground leveling area is equal to the size of the location.

- *Propose technical criteria in the drainage system planning project:* The technical standards are determined by the typical flow indicator for the urban cover surface and based on the urban design. Technical indicators base on land function. Each surface type has a flow indicator accordingly.

3.3. Propose to improve the national management ability for elevation controlling

**** Completing the management organization structure***: Completing the organizational structure of specialized agencies for urban elevation management, including:

- *Urban Department of the Hanoi People's Committee:* organized into six groups of fields: (1) Planning - Architecture; (2) Construction investment, housing, and urban development; (3) Traffic management; (4) Technical infrastructure; (5) Environmental management and mineral resources; and (6) Land sector.

- *Division of Technical Infrastructure Planning - Department of Architectural Planning*: consists of four specialized groups, including (1) Transportation, construction boundaries, right-of-way planning; (2) Urban elevation, water supply, drainage system; (3) Electricity supply, communication, urban lighting, urban greenery; and (4) Solid waste and urban cemeteries.

- *Division of Technical Infrastructure - Department of Construction*: Consists of five specialized groups, including (1) Urban transport infrastructure, underground facilities, management and use of urban technical infrastructure; (2) ground elevation, water supply, rainwater drainage, wastewater drainage; (3) Lighting and urban greenery; (4) Solid waste, environmental sanitation, and urban cemeteries; and (5) construction management and geographic information systems (GIS).

• *Division of Urban Management in People's Committees of districts*: Organized into four specialized groups consist of (1) Planning - Architecture (2) Technical infrastructure; (3) Construction activities; and (4) Transportation. The structure and connection among departments to implement urban elevation management is shown in Figure 3.6.

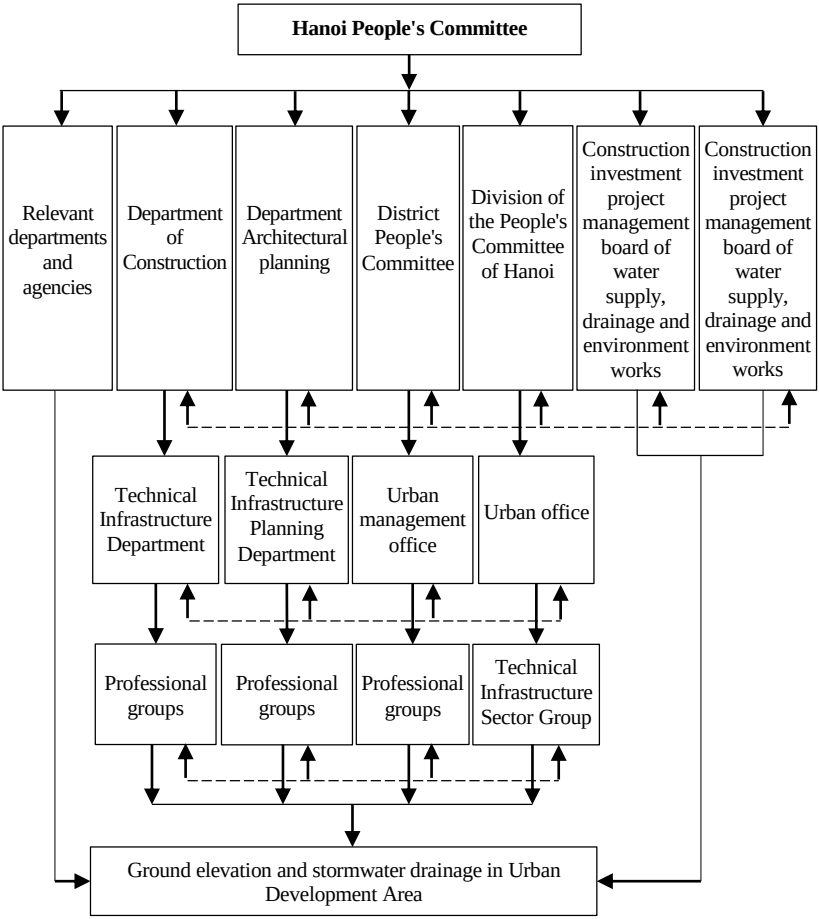

Figure 3.6. Hierarchy diagram of urban ground elevation management

**** Applying GIS geographic information system in urban elevation management.***

- *Develop the GIS database system:* The Technical Infrastructure Department under the Department of Construction is responsible for synthesizing information to build the GIS database and apply it in management.
- *Implementation management:* The professional team in the Technical Infrastructure Department of the Department of Construction account for developing and managing the database system. This team is also responsible for cooperating with relevant departments to organize and provide information during the construction permitting process.

**** Ground elevation management with community participation.***

The community could participate in proposing the urban ground elevation management in planning and implementing stages.

3.4. Apply urban ground elevation management solution to minimize flooding in Planning plot 19.1 of Bac Lam New urban area - Phu Luong Ward - Ha Dong District.

**** Introduction of the study area***

- *Location, limitation of the research area:* belongs to Bac Lam new urban area located within the administrative boundaries of Phu Luong ward, Ha Dong district, Hanoi city. Location of Planning Plot 19.1 is shown in Figure 3.9.

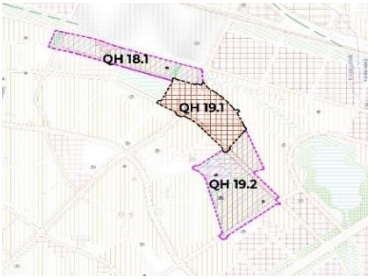

Figure 3.9. Location of planning plot 19.1

- *Natural conditions, current Status:* The slope gradually lowers from the Northwest to the Southeast. The location is mainly covered by rice fields and ponds, which is suitable for developing the retention pond and green space towards sustainable urban development.

• *Approved planning:* The planning of this study area was approved by the Hanoi People's Committee in Decision No. 6777/QD-UBND dated September 28, 2017.

**** Application of GIS in urban elevation management***

Figure 3.11. Centerline landmark data

• *Building a database system:* includes three groups of data layers: (1) background; (2) land use, spatial architecture, landscape architecture, and urban design; and (3) urban ground elevation. Map data is collected from planning documents, edited, normalized, and converted to ArcGIS format (ESRI standard) and VN2000 coordinate system.

• *Elevation management of urban ground level to minimize flooding*

+ Elevation management of the urban ground according to the landmarks on the site:

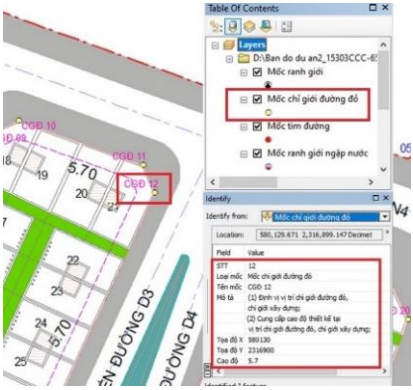

Figure 3.10. Red line marker data

- Elevation management according to the red boundary line, construction boundary line: through the landmark system integrated with approved ground elevation information. When extracting data, the information includes the type of landmark, landmark name; attribute description; x coordinate, y coordinate, and design elevation z (Figure 3.10).

Ground elevation management at the road centerline: integrated with approved ground elevation information through the centerline marker system. When extracting data, the information includes the

type of landmark, landmark name; attribute description; x coordinate, y coordinate, and design elevation z (Figure 3.11).

The ground elevation between contiguous urban areas, water surface areas, and retention ponds is controlled through the RG boundary markers integrated with approved ground elevation information. When extracting data, the information includes the type of landmark, landmark name; attribute description; x coordinate, y coordinate, and design elevation z (Figure 3.12). Water surface boundary management via the RGN landmarks and water surface properties, information displayed when extracting data includes: type of landmark; landmark name; attribute description; x coordinate, y coordinate, design elevation z, water surface area, highest water level Hmax, average water level Htb and lowest water level Hmin (Figure 3.13)

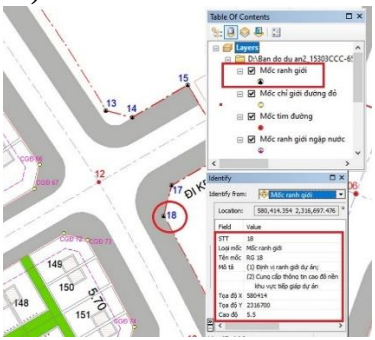

Figure 3.12. Boundary landmark data

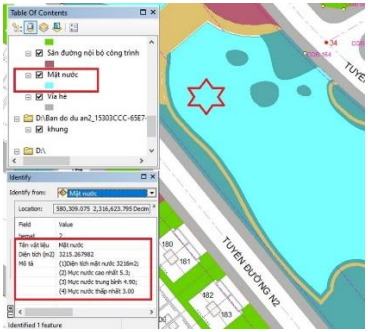

Figure 3.13. Air conditioner data

+ Management of technical criteria for ground leveling and surface water drainage

- Leveling area management: The works in the project are numbered according to specific route names. The building foundation is managed according to the number of houses that have been assigned the approved urban foundation elevation attribute. The information displayed when extracting data includes houses' number, type of

building, construction density, height, the elevation of the building's ground (Figure 3.14)

- Surface characteristic management: The cover type is assigned a flow factor. The information includes the name of materials used for each surface area, flow parameter, and the surface cover factor when extracting data. (Figure 3.15)

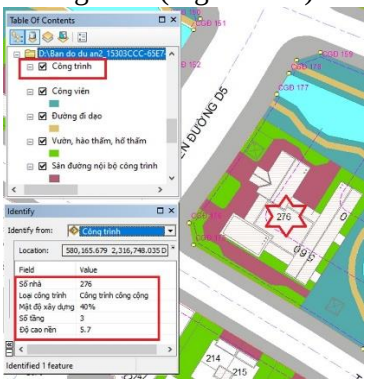

Figure 3.14. Construction data

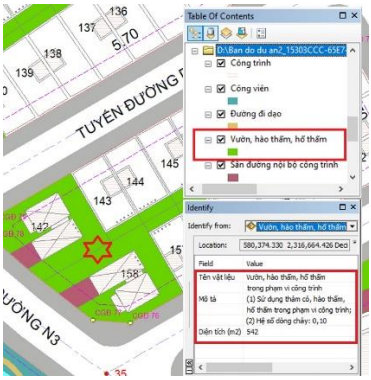

Figure 3.15. Surface data

3.5. Discussions

**** Supplement the content of marker planting and management of landmarks according to construction planning, which is related to the urban ground elevation level***

Additional contents of the implementation of landmark planting include: (1) Information of the approved elevation planning; (2) Add boundary markers in areas adjacent to urban areas with existing residential areas; and (3) Define the boundary of water surface area, the retention ponds, the areas subject to be temporarily flooded when raining and flooding, and the primary drainage axes of the urban area.

**** The proposed technical criteria in the planning project of urban surface elevation and surface water drainage.***

The thesis has established the criteria for leveling the ground according to the construction density criteria specified in QCVN 01-2008. Surface water drainage norms are selected according to the

provisions of urban design set in the Law on Urban Planning No. 30/2009/QH12 as a basis for functional agencies to formulate, appraise, approve and manage construction build. Technical criteria for ground leveling proposed by the thesis: (1) Technical criteria for ground leveling area in the plot and (2) Technical specifications for the temporary flooding locations in the green public areas. Technical criteria for stormwater drainage system proposed by the thesis: criteria for the surface characteristic of the construction site.

**** Improve the ability of elevation management***

The organization's structure ensures specialization and connection for each management level. The thesis proposes reorganizing the system's design: (1) By specialized fields for the Urban Department - Office of the People's Committee of Hanoi. (2) According to the specialized team for the Technical Infrastructure Department - Department of Construction; Technical Infrastructure Planning Department - Department of Architecture Planning and Urban Management Office under the People's Committee of districts.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

1. The expanded development area of South Red River - Centre of Hanoi has the highest urbanization rate, fast population growth rate, and a large land fund for urban development. In addition to spatial management requirements, land use needs to ensure the ability to connect technical infrastructure systems suitable for urban development. In particular, urban planning and management of urban elevation are considered critical in deciding drainage system solutions and reducing urban flooding. Therefore, the significance of the thesis is to propose solutions to manage urban ground elevations to minimize flooding in this area.

2. Based on data survey and field survey, the thesis defined four troubles of the planning and management of urban ground elevation: (1) Base elevation has been calculated to ensure resistance to urban flooding. However, local flooding still occurs in many places due to the uneven design elevation. (2) The economic and technical indicators of the ground leveling and stormwater drainage in the planning project have not been determined, which causes difficulties for formulating, appraising, and approving tasks. (3) Lack of the management basis for the elevation (information on the boundary markers) leads to difficulties in controlling and licensing the construction of the urban foundation elevation. (4) The centralized management system has a low specialization, and the participation of the community is still limited. The thesis has evaluated the overview of urban planning and management at the national and international scales. The research studied and developed relevant scientific information to propose solutions for urban elevation management and minimize flooding in the extended development area, south Red River, central Hanoi.

3. The thesis has proposed four groups of solutions for urban elevation management, including (1) Technical management; (2) Capacity of organizations in management; (3) Applying GIS geographic information; and (4) Participation of the community.

The details are as follows:

- *Propose technical management solutions:* Complete the content of implement boundary markers according to the planning. Meanwhile, the boundary marker information is supplemented with the urban background elevation content as the foundation for management. Propose technical criteria for ground elevation and drainage planning projects, including leveling area regulations and surface coverage coefficient criteria.

- *Improve the capacity of management:* Reorganize the system's structure into professional groups. The capability of the groups in different levels should be similar, which ensures high specialization, enhances connectivity, information exchange, and improves management efficiency.

- *Applying GIS in urban ground elevation management:* Develop the database to supply comprehensive information to authorities. Publish and transparent report of ground for businesses and people easy to access.

- C*ommunity participation:* Propose management process with community participation, includes the procedure of community participation in the planning process (4 steps) and in the implementation phase (3 steps). These processes demonstrate the critical role of the community in urban elevation management.

Based on the research objectives, the thesis proposed and developed solutions in managing the urban ground elevation to minimize flooding in the extended development area south Red River, central Ha Noi. The proposed solutions are novel and vital to improve the efficiency of urban elevation management in the study area and other cities with similar conditions.

Recommendations

1. *Recommendations to the Ministry of Construction:* Adjust the content of regulations in implementing and controlling the boundary markers according to planning. The height of the ground should be added when the landmark is provided. The boundary line to determine the contiguous boundary between the new urban area and the existing residential area should be added. The edge to define the water surface area, the retention ponds, the area subject to be temporarily flooded, and the primary urban drainage axes should be provided. The adjustment creates an essential legal basis

to control the ground elevation throughout the territory. Develop technical criteria for urban ground elevation planning projects and urban surface water drainage network planning to create a legal basis for implementing urban ground elevation planning and management.

2. Recommendations for Hanoi authorities: Promulgate regulations on reorganizing the system structure into professional groups and specialized groups. Similar capability in different group-level enhances the efficiency in urban infrastructure and elevation management. Department of Construction should be responsible for database management as well as connect with other organizations to propose criteria, technical guidelines, and regulators in providing information.

3. Recommendations to consultant companies and management agencies: The consultants are responsible for calculating the technical criteria of the ground leveling and surface water drainage, then appropriately apply in the urban construction planning project. The requirements should be clearly shown from the preparation stage to the planning project stage. The management agencies carry out the elevation management of the urban base following the approved planning scheme. Implement boundary markers according to planning documents with complete information and regulations on urban ground elevation.

4. Recommendations to the residential communities: The residential community should initiative participate in the management of urban elevations, follow the process from construction planning to the implementation stage.

LIST OF PUBLICATIONS

Professional journal articles

1. Chu Van Hoang (2017), *Current situation in planning and managing the ground elevation according to urban development planning projects*, Construction Planning Journal, (No. 88), ISSN 1859 - 3054 .

2. Chu Van Hoang (2019), C*riteria of technical preparation in urban construction planning projects, Environmental and Urban Magazine*, (No. 120+121/2019), (New Ministry), ISSN 1859 - 3674.

3. Chu Van Hoang (2019), *Planning and management of ground elevation and stormwater drainage towards sustainable urban development*, Journal of Architecture & Construction Science, Hanoi Architecture University, (No. 35), ISSN 1859 - 350X.

4. Chu Van Hoang (2020), *Solutions to reduce inundation, maintain urban landscape environment - Perspective from urban elevation management*, Environment and Urban Journal, (No. 135), (No. New set), ISSN 1859 – 3674.

Scientific research activity:

5. University scientific research project (2019), *Teaching materials for Urban Planning*, Hanoi University of Architecture.