

## Studying Geological Conditions for Construction Works in Thai Nguyen City

Nhu Thi Lan Huong<sup>1</sup>

<sup>1</sup> Faculty of Civil and Environment, Thai Nguyen University of Technology, Thai Nguyen, Vietnam

**Abstract:** From the collected results, field drilling data, and experiments, the authors found that the phase clay layer is encountered in most of the drill holes in the area. The authors also built the relationship between the deformation modulus of clay from experimental results in the room and in the field. From there, it helps the designer to rely on the experimental results in the room to adjust and calculate the deformation of the building's foundation accurately and by the actual ground construction in Thai Nguyen. Simultaneously, the authors have successfully built a geological GIS database system for Thai Nguyen city including administrative boundaries, topography, infrastructure, traffic, hydrology, surface cover, and system. GIS database specialized in engineering geology: borehole stratigraphy.

**Keywords:** Geology, ArcGIS, soil layer, void coefficient, earth pressure.

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Date of Submission: 04-05-2022

Date of Acceptance: 18-05-2022

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### I. INTRODUCTION

Thai Nguyen is a first-class urban city of Vietnam in Thai Nguyen province, the 10th most populous city in the country, and the 3rd largest city in the North of Vietnam after Hanoi and Hai Phong. At the same time, it is the center of the midlands and mountains of the North of the country. In the future, Thai Nguyen will become a modern urban on par with major cities in the country and the region, the problem of construction development and especially underground works and high-rise buildings is inevitable. Thai Nguyen city has a long history of development, has changed its boundary many times, and has made many adjustments to the general planning (excluding local adjustments). In 1996, Thai Nguyen city was approved the general planning project, which was determined as a grade III urban center directly under the province. In 2002, it was upgraded to a grade II urban area. In 2005, the first adjusted master plan of Thai Nguyen city was prepared and approved, with the criteria of spatial orientation to 2020. In August 2012, Thai Nguyen province advocated adjusting the general planning of Thai Nguyen city for the second time. To improve the position of the city in integration, play an important urban role of the whole country, attractive to the region, as well as solve the problems of existing urban areas, it is necessary to pay attention to the work of urban planning. synchronous construction plan.



**Figure 1.** Current status of the city center

The preparation of urban infrastructure has not been synchronized. Some old urban areas are densely populated, affecting infrastructure and protecting the ecological environment. In the past time, the planning to build several new residential areas and resettlement areas has not been reasonable. It has affected the general development of the city.

Currently, the surface land fund of the central area of Thai Nguyen city is in an almost exhausted state. Green spaces, public spaces with the need for modern civilization, and urban beauty are demanding the development that must be directed towards the ability to take advantage of parallel development in both height and depth. In particular, the issue of depth-development of urban underground space in Thai Nguyen is happening very new, inadequate, lacking planning and regulatory framework. Thai Nguyen will build underground works for traffic, water supply and drainage, commerce, services, and car parking. From the incidents that happened with big cities like Hanoi and Ho Chi Minh City, Thai Nguyen also needs to find its orientation.

Challenges for the construction industry in Thai Nguyen have also been raised, which is the problem of construction planning and the quality of construction works. To improve efficiency in construction work, geological survey work must be one step ahead. The formation of high-rise buildings is the trend that the city is aiming for. However, how much to develop high-rise buildings to match the development needs and ensure the infrastructure of the city, so far there is no specific plan. It is necessary to prepare for the survey to have specific statistics on traffic density and infrastructure conditions in central street areas. This is the basis for evaluating whether the construction of high-rise buildings in that location is suitable for geology and infrastructure conditions.

Previously, engineering geological investigations were conducted by the Department of Geology of Vietnam, but the documents are general and focus on mineral geology. They have not been integrated into the software and do not meet the construction forms of today. Therefore, it is difficult to use existing documents for planning and construction. From that fact, it is very necessary to study the geological and engineering conditions of the region to serve the sustainable development of the Thai Nguyen urban area.

## II. METHODOLOGY

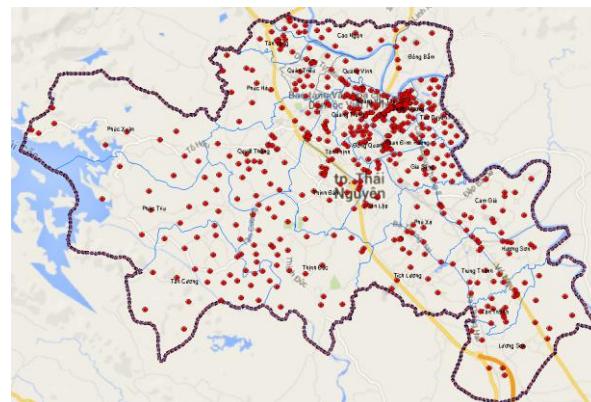
### **2.1 Collect existing data**

The collection of engineering geological survey documents has been available in the study area to reduce the volume of engineering geological survey work. On the other hand, this work brings economic efficiency, avoiding waste due to duplication between geological exploration works. The collected documents are guaranteed to be complete, accurate, and clear. The collected documents include all documents related to the geotechnical conditions of the study area, including:

- Documents on geology, stratigraphy, topography, hydrogeology of the area, map of the current state of the study area.
- Documentation of geological survey works that have been and will be built in the study area.
- Floor plan of the city center.
- Documentation of soil sample testing in boreholes at construction sites.
- Mineral geological map of Thai Nguyen province has been digitized on Mapinfo software.
- Collecting experimental data of soil and rock samples of 1000 drill holes, each hole is 10-50m deep.

### **2.2 Analysis of geological features of the study area**

Based on the collected documents and geological data, the authors have conducted actual drilling and surveying and analyzed the general characteristics of the geology of the area



**Figure 2.** Location map of collected boreholes and drill holes conducted in the study

The study area is divided into soil layers with the following characteristics:

**Layer 1:** Cultivated land, backfill soil, pond mud.

It is composed of backfill soil, silty soil, old fields yellow brown red brown gray brown yellow. Do not take samples for testing in this soil layer. Removed during construction design

**Layer 1a:** Soft plastic clay

It has a composition of mixed clay with yellow-brown red brown gray brown yellow color. Do not take samples for testing in this soil layer. Removed during construction design.

**Layer 2:** Mixed clay, hard plastic, medium, and weak structure.

Clay mixed with gray-brown, dark gray color, hard plastic state, medium-weak compact structure. This class is found in most of the survey areas.

**Layer 3:** Mixed clay, hard plastic, medium compact structure.

This layer is composed of clay mixed with yellow-grey brown-yellowish-brown, red-brown, in the hard plastic state, medium-tight structure, weak in some places. This layer distributes most of the survey area.

**Layer 4:** Fine-grained coarse sand, medium-tight texture, sometimes less tight.

This soil layer is composed of coarse-grained sand of gray-brown, gray-green color, the texture is medium and sometimes less tight. This layer is found in boreholes in the areas of Phuc Xuan, Thinh Duc, Thinh Dan, Tich Luong, Quan Trieu, and Tan Long communes.

**Layer 4a:** Coarse sand mixed with gravel, medium compact structure.

This soil layer is composed of coarse-grained sand and gravel, gray-brown, gray-white in color, medium compact in texture. This layer is only found in Phuc Xuan, Thinh Duc, and Thinh Dan communes.

**Layer 5:** Clay mixed with siltstones, semi-hard, medium-tight.

This soil layer is composed of clay mixed with a few weathered siltstones of yellow-brown, gray-green color.

**Layer 6:** Weathered siltstone interspersed with phased clay circuit, hard and tight state.

This soil layer is composed of weathered siltstone of gray-brown, blue-gray colors interspersed with phased clay circuits, solid state, tight structure. This soil layer is distributed in Tan Long, Quan Trieu, Phuc Ha, Thinh Dan, Tich Luong, Thinh Duc, Thinh Dan, and Phuc Xuan wards. Sampling in the drill core and testing the siltstone clay sample is:

One-axis instantaneous compressive strength:  $R_n = 250 \text{ kG/cm}^2$

Saturated single-axis instantaneous compressive strength:  $R_n \text{ saturated} = 150 \text{ kG/cm}^2$

Conduct standard penetration test (SPT) in the field in this layer for the following values: NTB > 50 (hammer/ 30cm).

**Layer 7:** Claystone is cracked, cracked, hard state, tight structure.

This soil layer is composed of claystone, cracked and broken, gray-brown, gray-green, hard state, tight texture. This class is located in Cam Gia, Phu Xa, Thinh Dan, Tich Luong, Thinh Duc, and Phuc Xuan wards.

Sampling in the drill core and testing rock samples are:

One-axis instantaneous compressive strength:  $R_n = 300 \text{ kG/cm}^2$

Saturation single-axis instantaneous compressive strength:  $R_n \text{ saturated} = 200 \text{ kG/cm}^2$

For grade 7 when calculating, it is recommended to choose compressive strength:  $R_n \text{ saturated} = 200 \text{ kG/cm}^2$

The field standard penetration test (SPT) in this layer gave the following values: NTB > 50 (hammer/ 30cm).

**Layer 8:** Claystone, hard state, tight structure.

This soil layer is composed of claystone, blue-gray, dark gray, solid state, very tight structure. We have in-hole sampling and rock testing.

One-axis instantaneous compressive strength:  $R_n = 550 \text{ kG/cm}^2$

Saturation single-axis instantaneous compressive strength:  $R_n \text{ saturated} = 450 \text{ kG/cm}^2$

**Layer 9:** Pebbles

Pebbles, gray, yellow-gray, very tight state. The thickness of this layer has not been drilled through.

According to the experimental results, the results of mechanical and physical parameters are as follows:

Specific weight ( $\gamma_s$ ):  $\gamma_s = 2,66 \text{ (g/cm}^3\text{)}$ .

Standard penetration resistance SPT ( $N_{30}$ ):  $N_{30} > 100$

The cobblestone layer has a very large total strain modulus  $E_0$ .

Standard calculation pressure:  $R_o = 6,0 \text{ (KG/cm}^2\text{)}$

**Layer 10:** Shale interspersed with limestone

Formation composition includes shale, thinly layered mineralized siltstone, microgranular limestone, clay limestone, in some places with coal shale, thin lens. Mineral composition includes calcite 95-97%, clay 3-5%.

Standard penetration resistance SPT ( $N_{30}$ ):  $N_{30} > 100$  (Hammer)

### III. EXPERIMENTAL RESULTS

#### **3.1. Establishing strain modulus relationship of clay from field and laboratory test results**

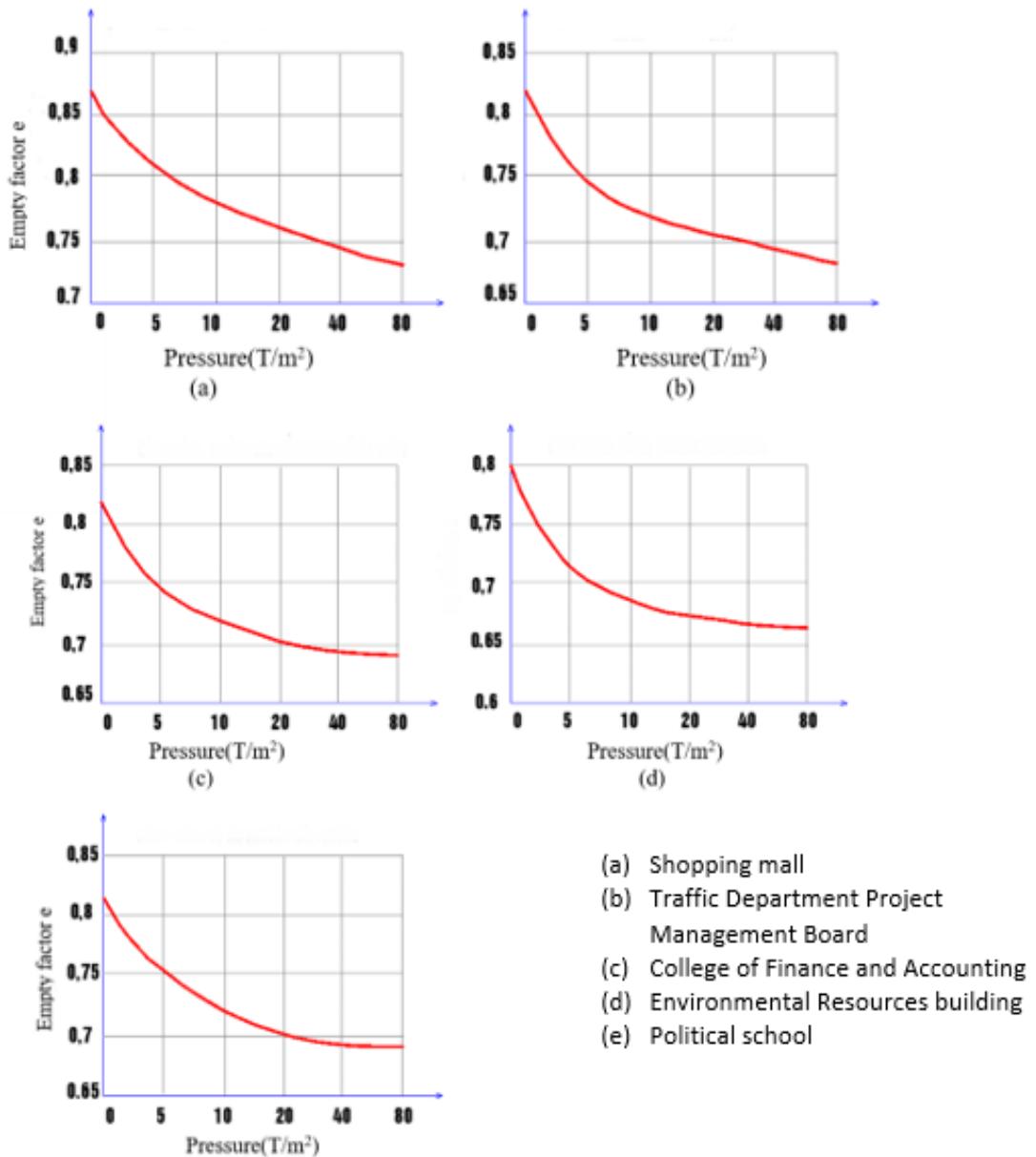
Calculation of deformation of the ground under the effect of construction loads is mostly based on laboratory test results, not considering the side expansion of the soil. From the results collected together with drilling and experimental data. We see that the phase clay layer is encountered in most of the boreholes. It is necessary to build a relationship between the deformation modulus of clay from laboratory and field test results. From there, it helps the designer to rely on the experimental results in the room to adjust and calculate the deformation of the building foundation accurately and by the actual ground construction in Thai Nguyen.

#### **Experimental results in the room**

The experimental results of 5 randomly selected works are summarized in Table 1. The stress-compression pressure relationship graphs are shown in Figure 3.

**Table 1** Experimental results in the room of soil mechanical and physical parameters of some buildings in the central area of Thai Nguyen

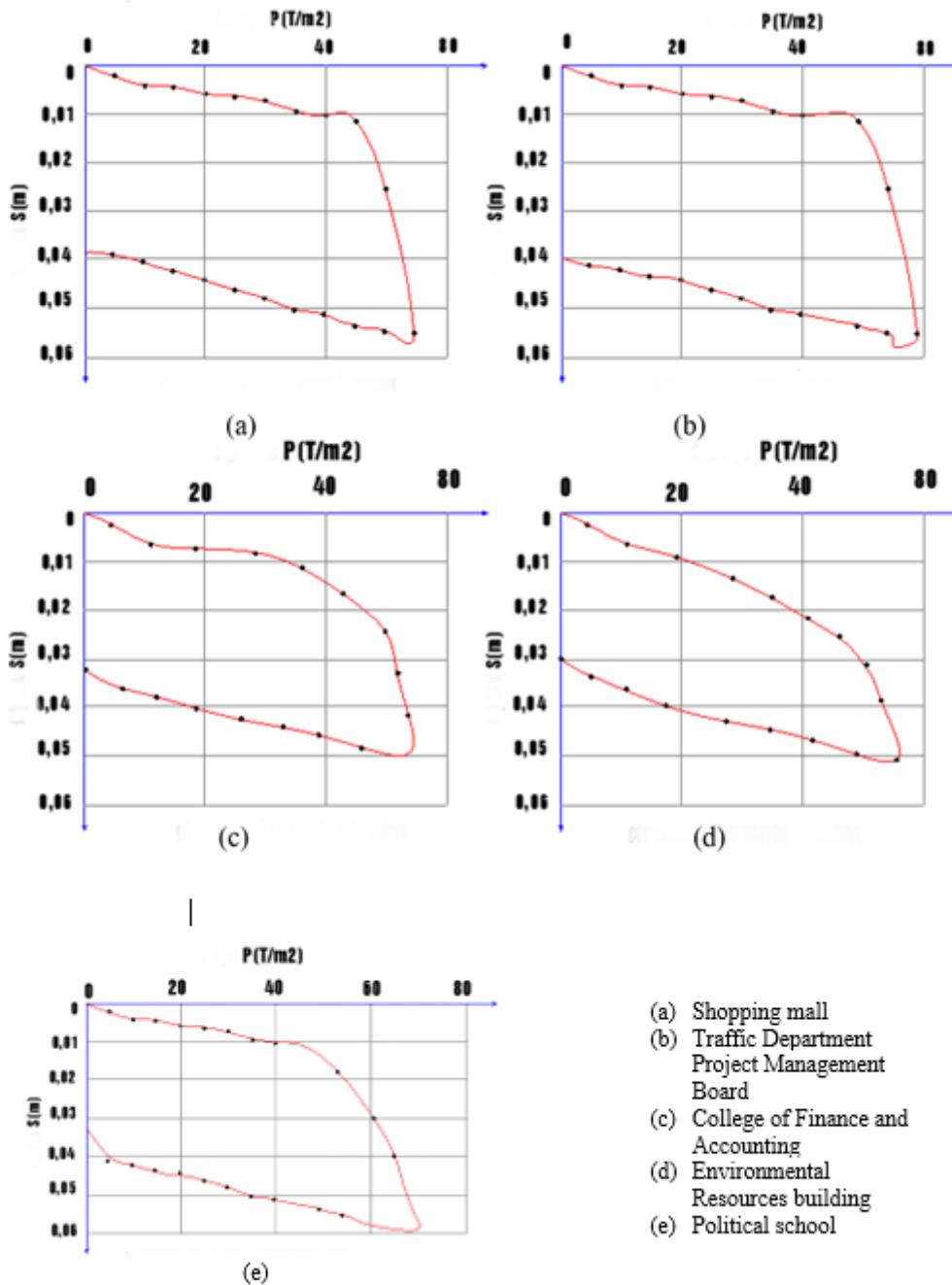
	Construction	W %	$\gamma$ $\text{g/cm}^3$	$\gamma_c$ $\text{g/cm}^3$	$\gamma_s$ $\text{g/cm}^3$	$e_o$	n %	$W_{ch}$ %	$W_d$ %	$I_d$ %	$I_s$ %	$\varphi$ $\text{Đô}$	C $\text{kG/cm}^2$	Type of Clay
1	Shopping mall	30.2	1.88	1.44	2.70	0.875	47	39.9	24.5	15.4	0.4	12°08'	0.180	hard plastic
		30.2	1.88	1.44	2.70	0.873	47	39.9	24.5	15.4	0.4	14°10'	0.190	hard plastic
2	Traffic Department Project Management Board	30.3	1.89	1.47	2.68	0.811	45	37.1	21.2	16.0	0.4	11°51'	0.196	hard plastic
		28.0	1.90	1.48	2.70	0.828	45	37.7	23.2	14.5	0.3	13°47'	0.204	hard plastic
3	College of Finance and Accounting	25.2	1.91	1.52	2.71	0.773	44	35.6	22.4	13.2	0.2	18°05'	0.230	half hard
		24.2	1.91	1.53	2.71	0.732	43	37.3	24.0	13.3	0.0	19°35'	0.237	half hard
4	Environmental Resources building	24.5	1.91	1.54	2.71	0.751	43	37.4	23.4	13.9	0.1	17°06'	0.223	half hard
		22.2	1.84	1.51	2.70	0.775	44	32.7	18.8	13.9	0.2	16°23	0.256	half hard
5	Political school	26.6	1.90	1.50	2.71	0.809	44	35.7	22.3	13.4	0.3	14°17'	0.201	hard plastic
		28.1	1.91	1.49	2.72	0.822	45	36.0	20.9	15.1	0.5	17°38	0.219	hard plastic



**Figure 3.** e-P relationship in consolidation compression test

#### Outdoor experiment results

The results of the field static compression table test are shown through the corresponding levels of compression pressure and settlement in Figure 4.



**Figure 4.** The results of the field static compression table test

### 3.2 Integrating geological data of Thai Nguyen into ARCGIS software

The geological GIS database system of Thai Nguyen city is designed into two parts:

-The GIS database system includes administrative boundaries, topography, infrastructure, traffic, water systems, and surface coverage.

-GIS database system specialized in engineering geology is borehole stratigraphy.

Name of the database:

Name of each group of specialized classes: du lieu dia chat thai nguyen

+ Base database group 1: Ranhgioiphuongxa

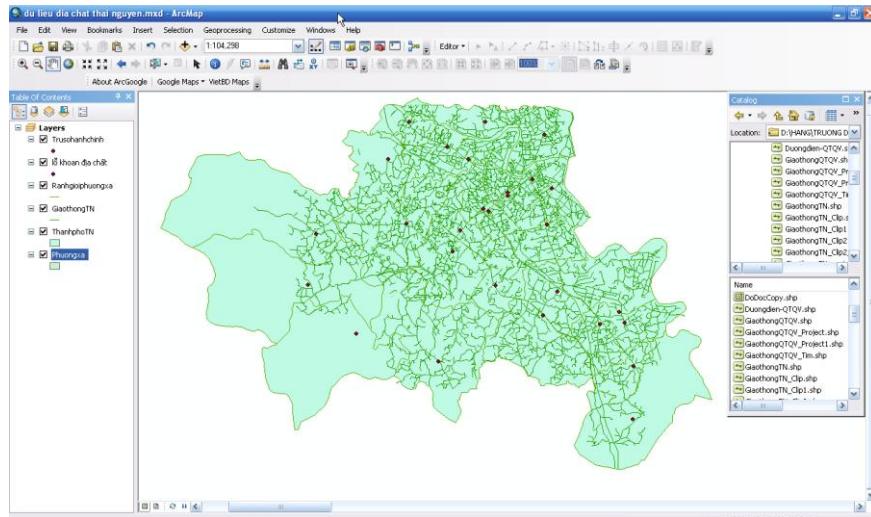
+ Base database group 2: Phuongxa

+ Base database group 3: GiaothongTN

+ Base database group 4: trusohanhchinh

+ Group of background databases 5: nhadan

+ Thematic group: lokhoandiachat



**Figure 5.** Importing data into ARCGIS 10.1

#### IV. CONCLUSION

The designer can rely on the experimental results in the room to adjust and calculate the deformation of the building foundation. The design will be more accurate and consistent with the actual ground construction in Thai Nguyen. According to the strain modulus relationship from the field and laboratory tests to calculate the foundation.

- For hard plastic phase clay with average void ratio  $e=0.85$  : difference in strain modulus from field test and laboratory test  $k_E$  from 3 to 3.8 times.
- For semi-solid phase lightning with average void ratio  $e=0.75$ : difference in strain modulus from field test and laboratory test  $k_E$  from 2.7 to 4.5 times.
- The higher the pressure level, the smaller this difference is.

Dividing the base structure of Thai Nguyen city into 3 types of features and geological data of each borehole are managed in Arcgis software. This creates favorable conditions for the foundation designer. Designers can serve as the basis for designing planning schemes and underground works planning.

#### Conflict of interest

There is no conflict to disclose.

#### ACKNOWLEDGEMENT

This work was supported by Thai Nguyen University of Technology, Vietnam.

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Nhu Thi Lan Huong. " Studying Geological Conditions for Construction Works in Thai Nguyen City." *International Journal of Engineering and Science*, vol. 12, no. 5, 2022, pp. 17-24.