Research Inventy: International Journal of Engineering And Science
Vol.13, Issue 2 (February. 2023), PP 04-11
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Working platform design -Verification by static and dynamic plate load testing,case study Tirana,Albania

Emanuela Zeraj [1], Xhuljana Koleci [2], Klodjan Xhexhi [3]
[1] *Structural Engineering/ Polis University, Albania*
[2] *Structural Engineering/ Polis University, Albania*
[3] *Architecture & Design/ Polis University, Albania*

Abstract: *The foundation of a building connects the main body superstructure to the ground. Every form of foundation and footing has a unique application in a given location for a certain weather condition. Understanding the foundation work is crucial for carrying out building activities.Due to the variety of structures they support, foundations are frequently built in different subsoil conditions and are exposed to static loads. The proper evaluation of soil bearing capacity is fundamental to the construction of various buildings. One of the quick, easy, and affordable ways for determining soil carrying capacity is the plate load test.*
The effect of subsoil conditions on the test results is assessed and analyzed in thorough parametric investigations. An overview of axial static and dynamic plate load testing will be given in this study. This article presents detailed processes and schematics. In an effort to highlight the differences and shared characteristics of the results, computational test results of the static load plate test and the dynamic load plate test are contrasted.
A load cell, a steel plate, a hydraulic actuator mounted on a big truck to apply load, a load cell to measure the load, and one or more linear variable displacement transformers to measure the vertical displacements make up the test setup. The maximum thrust load that should be applied to a fixed or stationary actuator when it is not moving is known as a "static loadDepending on the actuator's static load capacity, we can determine what a safe load is.The maximum thrust load that should be applied to the actuator while it is moving is known as a dynamic load. Dynamic load capacity refers to how much force an actuator can exert when driven and extending or retracting.
With each method's benefits and drawbacks considered, it can be determined that using them in various situations and agreeing to the confrontation of these tests for the purpose of comparing results, is the best course of action in order to have a base that satisfies the construction standards.
Keywords**:** *Foundations,load plate test,detailed procedures,soil-structure interaction, static load, dynamic load.*

Date of Submission: 26-01-2023 Date of Acceptance: 09-02-2023

I. INTRODUCTION

Foundations are needed to support heavy structures such as bridges, large buildings, and civil infrastructure. Although predicting the ultimate bearing capacity for framed buildings and equipment foundations is the main topic of this article, the same concepts may be used to determine the bearing capacity for other structures such as tower bases, dams, and fills. Meanthene foundations are hidden ones and few few scientists provide data to the massive structures and feats of engineering frequently under familiar cityscapes.[7]

The weight and other cargo conditions of these structures must be transferred to the natural subsurface geomaterials, using a stable and economical foundation system.[3]

A proper understanding of the strength and stiffness of the underpinningpoint-specific soil and rock is essential. Although much of this understanding can be attained by probing the subsurface materials.[5]

Full-scale axial load testing is often the best way to drop uncertainty and arrive at the optimal foundation design. Meeting the PLT standards provides some insight into the level of compaction quality of the superstructure materials, which in turn provides some insight into the bearing capacity and lifespan of the future structure. [6]

This method was proposed during the early 1920s by the engineer O.J. Porter of the highway department of California. Since this date, both in Europe and in America, the method is widespread and is a way of classifying soil to be used as a subgrade or base material such as in road construction.[9]

It's an adequate method to determine the support capacity of a material even in the place where it will be subjected to the stresses of the structure it will support. This test method was the standard test for numerous decades, and utmost of the provisions and regulations on compaction control relate to it.

The static load plate test, however, has a few drawbacks.The test forecasts how soil that is less than twice the width of the bearing plate deep will behave. However, in actuality, a foundation's effect zone extends considerably more below the surface.

Since the plate load test is only conducted for a brief period of time, it is unable to forecast settlement over a longer time frame, particularly for cohesive soil. [11]

On the other hand, to remedy this shortcoming, several innovative compaction control methods, based on the dynamic soil response, have been developed in recent times.

In addition to the conventional static load plate test, the dynamic load test with the light-falling weight device will pose threats to that method.[4]

Load bearing capacity and compaction quality of soil,non-cohesive sub-bases, and soil advancements can be measured within a matter of three minutes, so it makes a large number of tests possible compared to the conventional static load plate test. With a lightweight deflectometer, our compaction work can be specifically steered and monitored. This provides certainty and saves time and money. It can be handled easily and also operated by one person indeed without any former knowledge due to the rearmost technology. [10]

In this paper, both the static and dynamic load plate tests are investigated utilizing detailed procedures and schematics done by "Sarp&Lab" on two structures, which are presently under construction by "Pepa Group" sh.p.k located in Tirana.

II. EXPERIMENTAL PROCEDURE

1. The static load plate test

1.1Test procedure

No matter how careful the engineers are with derivation of the calculations, they must always go out in site and do full scale validation.This testing confirms the final limit structure design, thus there must be 100% confidence in the safety margins incorporated into the design.

Figure 1: ‘’Stairway to the sky palace’’ St: Brigada VIII ,Tirana ,Albania(Source:Author)

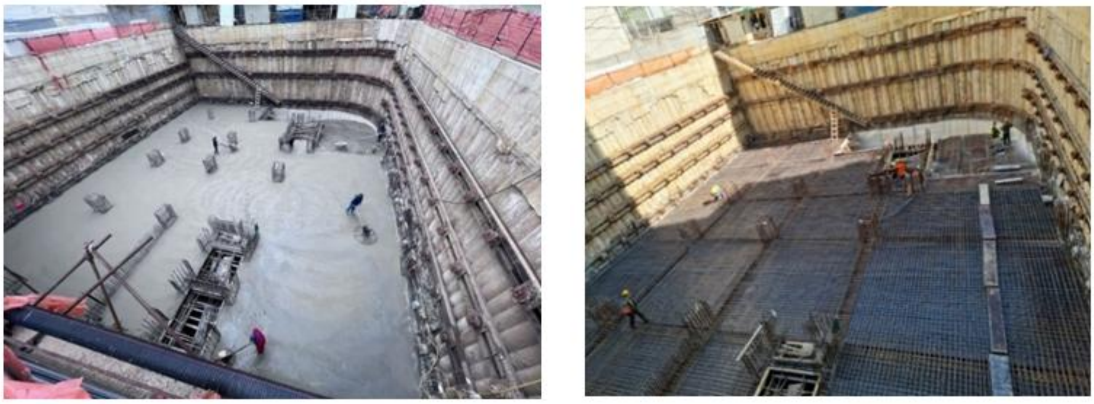


Figure 2: Plate load test. (Source: Author)

Figure 3: Location of thebuilding. St:’’ThimiKrej’’,Tirana (Source: Google map)

Figure 4: Concept of what is going to be. (Source: Author)

The first thing in need is a reaction load and, in such case, it is used an excavator (see Fig. 2). The intent is to use it as a reaction load to push the plate into the ground. Next is needed to prepare the ground in order to become a nice flat area. Furthermore, to make sure that the entire plate is in direct contact with the surface of the entire soil.

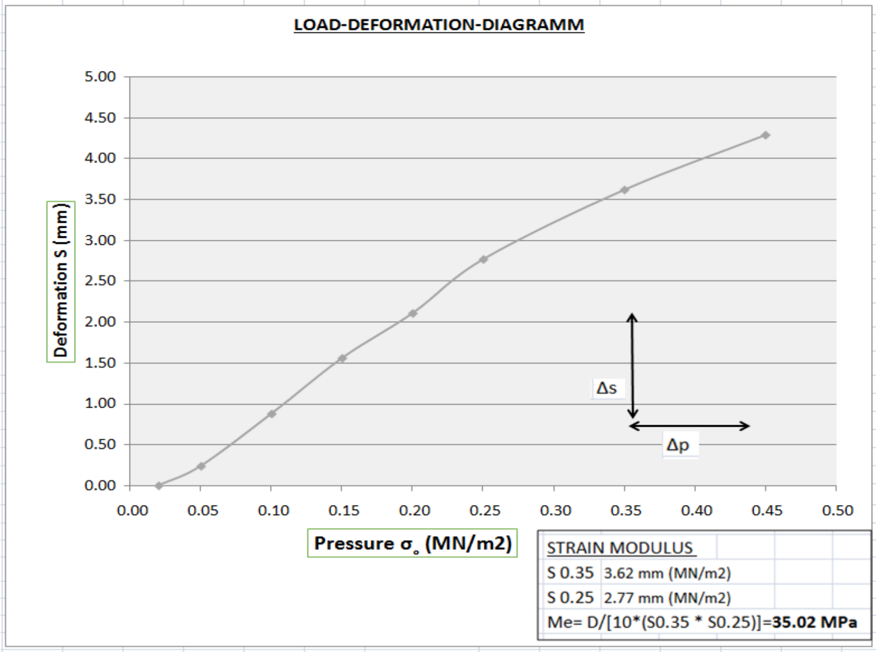
Figure 5: Equipment, (Source: Author & Google)

Testing is done by placing a circular load plate made of steel with a diameter of 600 mm on the planar subsoil(see Fig .5).
According to the technical requirements,this one will provide a zone of influence under the plate of about 1.2 meters. It´s not preferred to use a smaller plate because the data about the depth of influence will be corrupted. [2]
The first load of 1.41 KN (see Fig.5) will last until the settlement virtually ceases. The second load will be higher 3.53 KN.Due to settlement monitoring data are gathered in the below table.In order to move up to the next load increment it will be used the hydraulic pump (see Fig.4) until it is provided the required level on that loadout.It is observed how pressure cylinderrises, lifting the reaction load up(excavator)and pushing the plate into the ground.
The average normal stress belowthe plate, σ0, is plotted against the settlements, for each load increment in order to obtain a load-settlement curve. According to DIN 18134 [6] to determine the strain modulus, Ev, the load shall be applied in not less than six stages, in approximatelyequal increments, until the required maximum normal stress is reached. Each increase in load (from stage to stage) shall be completed within one minute. The test consists of 8 stages (see Table and Graphic.6).[8]

Figure 6: Load-displacement table and diagrammof tested soil. (Source:Laboratory"Sarp&Lab")

TESTING DATE: **16.09.2022**
TEST: **STATIC PLATES - STRAIN MODULUS**
TEST STANDARD: **CNR-B.U. n**◦146
TESTING LOCATION: **IN FIELD**
ENVIRONMENTAL CONDITIONS:
TEMPERATURE: **26.9**˚C
HUMIDITY: **65%**

SAMPLES DESCRIPTION: *PLATE DIAMETER:*		*BASE MATERIAL* *0.300 M*			*MANOMETER READING:* *Mpa, KN*
PRESSURE σ_0 (MPa=MN/m2)	**FORCE F (KN)**	**SETTLEMENT S (0.01 mm)**			**AVERAGE PROGRESSIVE Sc (mm)**
		S1	**S1**	**S1**	
0.02	1.41	0.00	0.00	0.00	0.00
0.05	3.53	0.27	0.20	0.24	0.24
0.10	7.07	0.60	0.63	0.69	0.88
0.15	10.60	0.70	0.64	0.71	1.56
0.20	14.14	0.55	0.54	0.57	2.11
0.25	17.67	0.66	0.67	0.63	2.77
0.35	24.74	0.86	0.89	0.82	3.62
0.45	31.81	0.67	0.69	0.65	4.29



1.2 Evaluation of the static load plate test

From the settlement s of the rigid circular plate, which is loaded by a concentrated force P the Young's modulus E can be determined according to the theory of elasticity

$$E=\frac{P}{rs}*\frac{1-v^2}{2}$$

r - is the radius of the loading plate, in mm;
v-is Poisson's ratio of the subsoil;

Assuming that the pressure P below the load plate is uniformly distributed, we have:

$$P=\frac{P}{r^2\Pi}$$

Furthermore,assuming that the Poisson's ratio is constant for all soils with m = 0.212, the so-called deformation modulus Ev can be defined as:

$$E_v=1.5r\frac{\Delta p}{\Delta S}\cdot$$

In the above expression pressure p and settlement s are replaced in this equation by their increments Dp and Ds since the soil behavior is nonlinear. In practice, according to Fig. 5, the deformation modules Ev1 and Ev2 are calculated from the first and second loading branches of the load-displacement diagram. It is specified that the pressure increment Dp and the corresponding deformation increments Ds1 and Ds2 are provided off from therecorded diagram. The soil compaction is assessed through the modulus Ev1 and the module ratio Ev2/Ev1.[I]

1.3Assessment of the static load plate test

Par experience shows however that the assumptions and simplifications of the test evaluation as described above are not satisfactory for the following reasons:

- The subsoil and built-in material do nor behave as a linear elastic one. The stiffness depends on the magnitude of the applied load.
- During the test, the material is deformed plastically in the direct vicinity of the load plate.
- The layerwise construction leads to composite earth structures, where the material properties may change from layer to layer. The homogeneity of the subgrade is not ensured.
- The subsoil is compacted and stiffened during the test. During the test evaluation, the loading history plays a significant role.
- The load is applied through a hydraulic jack, which is supported by a counterweight. The soil is loaded below the plate, however, unloaded at the position of the counterweight. Thus, the halfspace is not loaded globally, but the load is only locally re-distributed.

• The frame itself, where the measurement gauges are fastened and which serves as the reference plane, moves during the test, making it impossible to measure the absolute settlement. As a result, the soil compaction and deformation modulus are frequently overestimated.

2. Thedynamic plate load test

In order to assess the soil carrying capacity and compaction quality of soils as well as for soil improvement applications, dynamic test procedures are employed in earthmoving and road construction.

Fig. 7: Dynamic plate loadtest. (Source:Author.)

Figure 8: Location of thebuilding.St:''BulevardiGjergjFishta'',Tirana. (Source :Author.)

Figure 9: Concept of what is going to be. (Source :Author.)

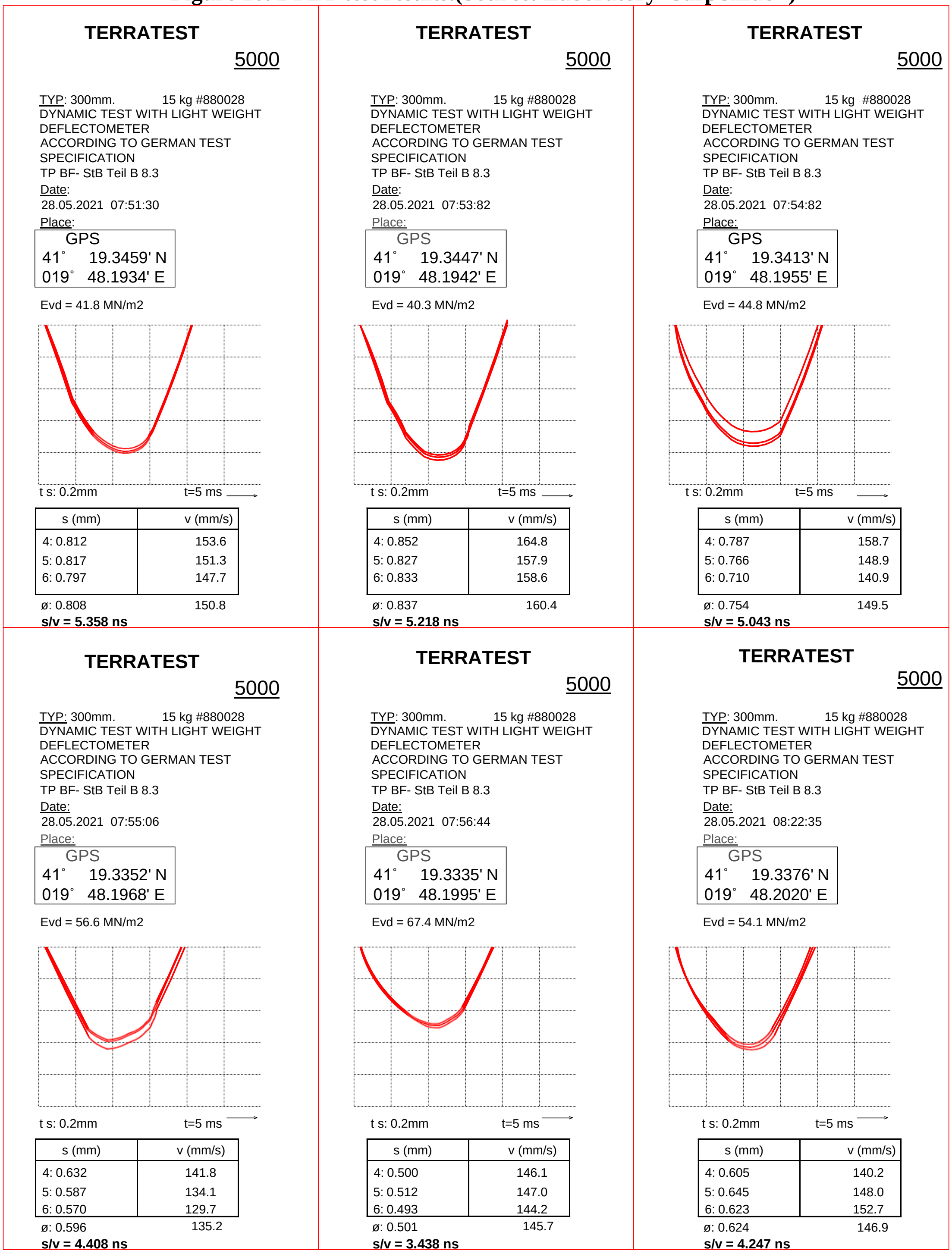
2.1 Test procedure

The device's major parts are a guide rod, a falling weight, a steel or synthetic material spring-damper element, a load plate (a circular steel plate), and a load plate.
The set-up is shown in Fig.7.
For this test a load plate with a 300 mm diameter is used. First, it is laid down the full-size load plate than is putted the loading mechanism on to the load plates and release the transportation lock (see Fig.7). Furthermore, it is connected the measuring instrument with the load plate and switch on the device. The load is generated by a damped impact. The impact activates inertial forces in the earth and the tester, impacting the resultant movements.
Hence, load bearing capacity can be measured within a matter of two minutes. It is needed just to put in place, measure and printout.
The printout includes the following data(see Fig.10):
-The current date and time
-The GPS coordinates of the point for measuring the settlements
-The settlement(sn)

-The settlement rate(vn)
-Average value(Mw)
-The dynamic deformation modules(Evd)
-The speed ratio(s/v)
-The settlement curves

The engineer decides on the quality and continuation of the construction projects based on these measured values without waiting for time-consuming laboratory results.

Figure 10. DPLT test results.(Source: Laboratory"Sarp&Lab")



2.2 Evaluation of the dynamic load plate test

The dynamic plate-load test can be used to assess the bearing capacity and compaction quality of soils in subterranean and substructure during earthmoving and road building.Modules of deformation dynamic Evd is a metric for the soil's deformability when subjected to a certain vertical impact load with a maximum impact duration tmax. According to the formula below, its value is determined using the load plate's maximum settlement, smax.:

$Evd = 1.5 * r * \sigma max / smax$

where:

smax - average value of the settlements smax1, smax2, smax3 out of 3 measuring impacts (after 3 preloading impacts);

r - is the radius of the loading plate, in mm;

σ max - normal stress under the load plate. [1]

III. COMPARISONOF RESULTS

The evolution of the deformation modules Ev from the static load plate test and of the dynamic deformation modules Evd from the dynamic load plate test with respect to the layer thickness d are set in contrast. It can be seen that for a perfect homogeneous soil medium, the dynamic deformation modules (Evd) is greater than the deformation modules (Ev), which is equivalent to the Young's modules for m = 0.212. This results from the highest deformation occurring after the peak soil contact stress. However, this deviation is of methodic nature, and thus can be considered in regulations and provisions. Increasing the layer of thickness the difference between both moduli becomes more pronounced. Evd is greater than Ev for all layer thicknesses in soil stratifications where the layers are stiffer than the underlying halfspace.

IV. CONCLUSIONS

In order to assess the impact of layered earth constructions of varied stiffness on the test results, various numerical parametric simulations of the static and dynamic load plate tests have been carried out.

The static load plate test's deformation modules are not a pure material parameter; rather, they depend on a number of different elements, and are therefore primarily based on the criteria and agreements. This is especially important when comparing different compaction control methods with the static load plate test.

Finding a correlation between the strain modules, Ev, and the dynamic modules of deformation, Evd, was required because there were two different types of testing procedures, each based on a different principle of load application, and one of them was noticeably shorter and more convenient than the other.

Static load tests are considered to provide the most accurate results, due to slower and more precise process. In comparison to The slower and more exact technique used in static load tests is thought to produce the results that are the most accurate. Dynamic load tests are substantially less expensive and take much less time to perform than static load tests. If dynamic load testing is done with static tests for each type of soil, Eurocode 7 allows for a reduction in design partial factors. The usage of both of them is advised because it is a long - term profitability.

In order to ensure the overall strength of the structure, a static load test should be performed prior to dynamic load testing.

ACKNOWLEDGEMENT

The authors are grateful to the "National Council for Scientific and Technological Development"– CNPq.

REFERENCES

[1]. Prof. Dr. Luljeta Bozo, 2009. Gjeoteknika per degen arkitekture dhe mjedis (Geotechnics for the branch of architecture and environment).

[2]. Christoph Adam, Dietmar Adam, Fritz Kopf, Ivan Paulmichl , 2009. Computational validation of static and dynamic plate load testing. Acta Geotechnica 4:35–55, DOI 10.1007/s11440-008-0081-0.

[3]. Qasim Abdulkarem Al-Obaidi, Ali Al-Shamoosi, Azad Abbas Ahmed, 2017. Evaluation of soil bearing capacity by plate load test. Researchgate.net, DOI:10.1201/9781315100333-111.

[4]. A-Cs Nagy, N M Ilieș, A-P Cîrcu, V-C Ciubotaru and B M Crăciunescu, 2021. Static anddynamic plate loading tests of stabilizedsoil samples used for riverbank consolidation. IOP Publishing Ltd, DOI 10.1088/1757-899X/1138/1/012032.

[5]. Eldon Joseph Yoder, Matthew W. Witczak,1975. Principles of pavement design, Second Edition. A Wiley-Interscience Publication John Wiley & Sons, INC.,New York, London, Sydnei, Toronto, 75-12555 ISBN O-471-97780-2.

[6]. Herbjörg Andresdottir, 2019. Plate load testing. Norwegian University of Science and Technology.

[7]. Joseph E. Bowles, 1958.Foundation analysis and design,Fifth Edition. The McGraw-Hill Companies, ISBN 0-07-912247-7.

[8]. DIN Deutsches Institut für Normung e.V., Berlin. Beuth Verlag GmbH, 10772 Berlin, Germany, 2001.Determining the deformation and strength characteristics of soil by the plate loading test, DIN 18134.

[9]. Prajwol Tamrakar,2017. Evaluation of Mechanical Parameters of Contaminated Road Base and Railway Ballast. University of Texas at El Paso DigitalCommons@UTEP.

[10]. Pramod Kolase, Shama P S Mayank, K Desai, Atul K. Desai, Shivamanth Angadi, 2015. Study of the Light Weight Deflectometer and ReviewS. International Journal of Engineering Research and General Science Volume 3, Issue 6, ISSN 2091-2730

[11]. Jaroslaw Rybak, Maciej Król, 2018. Limitations and risk related to static capacity testing of piles – “unfortunate case” studies. MATEC Web of Conferences 146, 02006, DOI:10.1051/matecconf/201814602006.

Emanuela Zeraj, et. al. "Working platform design -Verification by static and dynamic plate load testing,case study Tirana,Albania." *International Journal of Engineering and Science*, vol. 13, no. 2, 2023, pp. 04-11.