

Analysis of the Use of Cobweb-Shaped Foundation for Road Pavement Construction

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ABSTRACT

Flexible pavement and rigid pavement are the two types of road construction pavement. This study attempts to employ Cobweb-Shaped Foundation (KSSL) as an alternative style of road construction, KSSL being the labor of the nation's youth and commonly used in structures. PT. Katama Suryabumi owns the building patent. This study attempts to incorporate KSSL, which has been widely utilized for building foundations, into road construction. The study was carried out by doing experimental comparisons and analysis using the Finite Element Method, in which the model is summarized in order to achieve accurate comparison findings, and it is believed that they will find a formula connected to the design of KSSL for road building. It is expected that this concept may be used to solve problems in designs that do not currently have regulations or standards. As a result, the study objectives are as follows: a) The KSSL foundation is a stiff pavement that may be used as an alternative pavement. b) Calculating the KSSL foundation's strength and settling. b) Restoring and improving the KSSL foundation.



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1. INTRODUCTION

Road infrastructure development is a key necessity in establishing Indonesia's transportation system; a robust transportation network will influence the growth of activities in an area. Road infrastructure construction, maintenance, and enhancement has become a priority initiative in response to the growing population and number of cars on the road [1]. The government is investing heavily in road infrastructure as the front line of growth, such as the vast building of toll highways and the Trans Papua Road [2]. With the expansion of road infrastructure, there will be an equitable distribution of development in each region, as well as rapid and seamless transportation of commodities. In general, there are two types of road pavement: flexible asphalt pavement and rigid concrete pavement [3], [4].

Flexible pavement is made up of an asphalt mixture on the surface and granular material on the bottom layer [5], whereas rigid pavement is made up of concrete as the main material of the pavement. Rigid pavement is typically utilized on roads with dense traffic and a high load distribution, which necessitates sophisticated and particular planning [6]. Both types of pavement frequently sustain damage as a result of heavy traffic loads and unstable soil types, so that both

pavement structures are unable to maintain their strength over long periods of time, eventually failing structurally and functionally, causing safety issues. and road users' comfort will be jeopardized [7, 8].

One example is the use of Cobweb-Shaped Foundation Construction (KSSL) as an alternative type of road pavement foundation in Indonesia, which was discovered in 1976 by Tyantori and Sutjipto and has been implemented in many buildings and runways in Indonesia since 1978. This KSSL has three ribs with different functions: construction rib, dividing rib, and settlement rib. In construction, it is used as part of the lower structure to place the construction above it and transmit the load of the upperstructure/superstructure to a strong enough ground to support it [9], [10]. This Cobweb-Shaped web structure, which is a shallow foundation with a Cobweb Shaped construction, offers benefits such as a short construction period, a simple design, and earthquake resilience [11], when performing foundation analysis, it is critical to understand the amount of bearing capacity and how settlement is related to its role as a construction load distribution to the ground [12].

Based on simulations using the finite element method and empirical formulas, KSSL foundations can be used in building construction on clay soil that is reinforced with woven geotextile reinforcement sheets. The reinforcement used increases the bearing capacity value and decreases the settlement value when compared to not using geotextile reinforcement sheets. weaved [13]. PLAXIS 3D FOUNDATION [14] can be used to do modeling analysis of the bearing capacity and settlement of KSSL foundations and drilled piles, where soil parameter data is required to aid the foundation handle the load, one of which is the Standard Penetration Test (SPT) test data [11].

Based on the aforementioned description, the author examined and studied cobweb construction (KSSL) as an alternative form of road pavement in Indonesia. The difference between this research and previous research is how the KSSL modeling is done using SNSF modeling simulations with two KSSL models without and with soil, then the displacement and stress that occurs in the structure, both concrete and soil, will be seen. This article is part of a literature review on KSSL research on concrete pavement.

2. METHODS

The road pavement structure is made up of layers that are laid on top of the sub-grade and have a sufficient bearing capacity, with each layer receiving traffic loads and dispersing the load, which includes the surface layer, top foundation layer, sub-based layer, and sub-grade [15]. In pavement constructions, KSSL is employed as a foundation. The existence of a rib system that works as a stiffener distinguishes the standard plate foundation type from the KSSL foundation. Climatic conditions can have a long-term impact not only on the performance of the road surface structure, but also on its responsiveness to loads. If you utilize an average plate construction as a foundation during the rainy season, the cavities between the plate and the sub-grade will fill with water, resulting in a drop in soil shear strength. As a result, a foundation structure that can provide a contact area between the slab and the ground throughout the duration of the road building plan is required. Indirectly, with excellent soil support strength, the pavement construction is assured to last the planned life.

This study combined experimental data with computational analysis using the Finite Element Method (MEH), and then validated the results of both approaches to generate theoretical parameters and calculations for cobweb construction pavement design (KSSL). The research work program is divided into many phases based on the research methodology depicted in Figure 1. The activity stages are as follows.

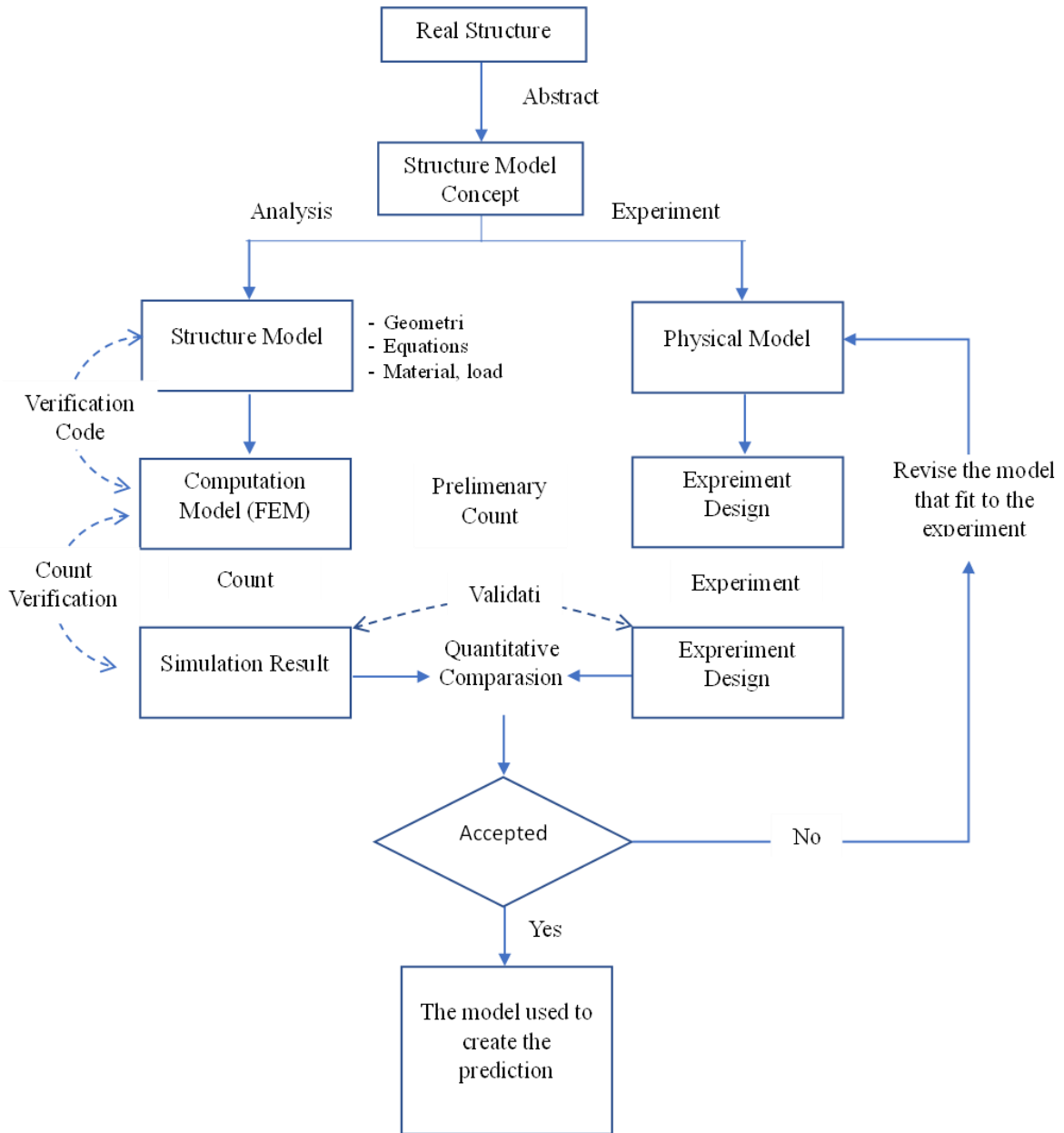


Figure 1. Research Flow Diagram

3. RESULTS AND DISCUSSION

3.1 Rigid Pavement

Rigid pavement is defined as pavement that uses cement as a binding agent and consists of concrete slabs with or without reinforcing placed on the subgrade with or without a subbase layer [16]. Rigid pavement is typically utilized on roads with high traffic volumes and a wide load distribution. This form of pavement frequently sustains damage from heavy traffic loads as well as unstable soil types, causing both pavement components to lose strength over time.

The load-bearing capacity of a cement concrete pavement is mostly determined by the concrete slab. The subgrade's composition, bearing capacity, and homogeneity have a significant impact on the endurance and strength of cement concrete pavement. During the service time, compaction water

content, density, and surface water content must all be considered. This pavement frequently sustains damage from heavy traffic loads as well as unstable soil types, causing the pavement structure to lose strength over time. Figure 2 demonstrates this. Crack damage in stiff pavement is one type.

The carrying capacity of a concrete pavement is mostly determined by the concrete slab. The subgrade's type, bearing capacity, and homogeneity all have an impact on the endurance and strength of concrete pavement. Compaction water content, density, and fluctuations in water content during the service duration are all factors to consider. The foundation layer beneath cement concrete pavement is not the main part that carries the load, but it does control the influence of swelling and shrinkage of the subgrade, prevent intrusion and pumping at plate joints, cracks, and edges, provide steady and uniform support to the plate, and serve as work floor pavement during construction. Cement concrete slabs have quite rigid characteristics and can distribute loads over a large area while causing little stress in the layers beneath [17]. The use of ribs as stiffeners distinguishes rigid pavement from KSSL, whereas rigid pavement frequently generates holes between the plate and the ground due to repeated stresses from vehicle wheels. The concrete plate is regarded as a flexible structure in stiff pavement, supporting the weight of the vehicle above it. The forces above the structural plate are totally transferred to the foundation layer and soil via the structural plate, which can be seen on Figure 3.

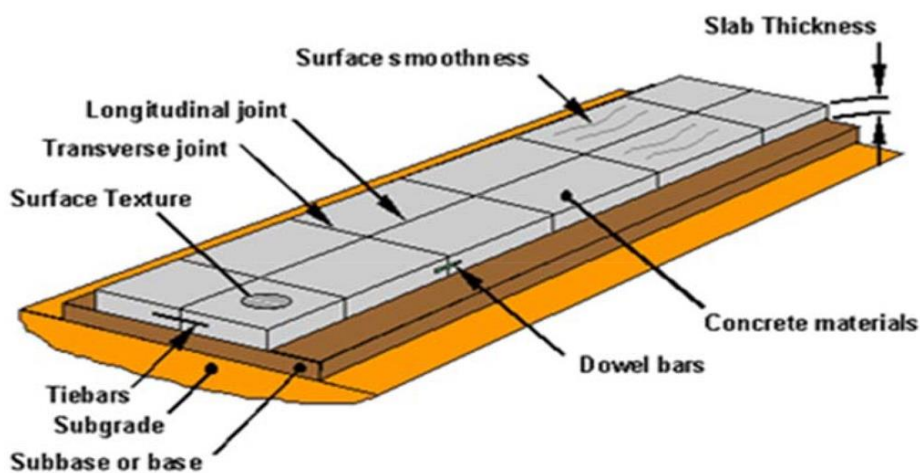


Figure 3. Rigid Pavement Structure

The subbase course is the layer that comes after the base soil and bears the load of the higher layer. On stiff pavement, the subbase layer is often a thin concrete plate measuring 5 cm - 10 cm above the subgrade, known as lean concrete. Because it protects against subgrade and water seepage, the thin concrete layer must have a good mixture. Before working on the surface layer, it is usually coated with plastic to prevent water seepage (pumping) and to protect the top surface from damaging the foundation soil layer [18]. The lower foundation layer on cement concrete pavement is not the main element that bears the weight, but it serves to:

- a. control the influence of subgrade swelling and shrinking
- b. Protects against entry and pumping at joints, fissures, and plate edges.
- c. Improves and uniformly supports the plate.
- d. As a construction work floor

3.2 Rigid Pavement Damage

Deterioration to roads that causes a loss in service owing to functional and structural deterioration, resulting in diminished comfort and safety for road users. The most typical causes of damage to road shoulder pavement built of stiff pavement are no longer stable soil conditions, water from rains, pavement construction materials, climate, and faults in the compaction process of the soil layer. is not good, a decline in concrete quality can also be a cause, and excessive stresses on the rigid concrete can also be a role in pavement degradation [19].

According to the Directorate General of Highways, 2017 is categorized into the following forms of road damage on rigid pavement:

1. Deformation is damage to the pavement surface caused by cracks or movement between slabs; examples of deformation damage include
 - a. Subsidence is a permanent reduction in the slab surface that is typically found at fissures or joints.
 - b. Pumping is a phenomenon in which water or mud escapes (is pumped) via joints or fissures caused by traffic-related slab displacement. Pumping can diminish the carrying capacity of the foundation layer because voids occur under the slab and are normally invisible unless it rains.
 - c. Rocking is the vertical movement generated by traffic in joints or cracks. Typically, rocking happens as a result of sinking or pumping of the supporting layer beneath the plate, resulting in the loss of support, which can lead to permanent fracture.
2. Cracks are a type of structural damage to rigid pavement that can be produced by a variety of factors, including inadequate subgrade and foundation layer bearing strength, and incorrect connection structure and function. When crack damage occurs, repairs must be made as soon as possible. If the seams or cracks are not closed, complete pavement degradation is highly likely, as seen in Figure 4. The following are the sorts of cracks that typically form in stiff pavement:
 - a. Block cracks are a sort of interconnected crack damage that generates a succession of rectangular blocks that are typically larger than 1m in size.
 - b. Corner cracks are cracks that run diagonally from an edge or longitudinal joint to a transverse junction.
 - c. Diagonal cracks are those that are not related and whose line cuts through the slab. The breakdown of this type of structure is caused by compaction of the fine sand base soil, which reduces its strength in supporting the plate.
 - d. Longitudinal cracks are unconnected cracks that propagate in the longitudinal direction of the slab, beginning as a single crack or a sequence of nearly parallel cracks.
 - e. Transverse cracks are non-connected cracks that propagate across the slab. Wide transverse fissures are more likely in Portland cement concrete pavement that lacks steel support for temperature variations.
 - f. Irregular cracks are solitary cracks that are not related and have an irregular pattern.
3. Damage to the joint filler can allow surface water to enter and cause hard material to enter, preventing horizontal expansion.
4. Chipping is damage that happens at the slab surface's edge, joints, corners, or cracks. The lump's depth can reach more than 50 mm.
5. Pavement edge subsidence is damage that happens on the shoulder near to the slab's edge where subsidence occurs.
6. Patches are sections of pavement that have been removed and refilled with filler material for pavement repairs, as seen in Figure 5.
7. Surface texture damage occurs as a result of the release of the concrete mortar, followed by the release of the aggregate in the damaged portion, and the wear and tear of coarse aggregate on the concrete surface, or as a result of the usage of round and smooth aggregate.



Figure 4. Crack Damage



Figure 5. Patch Damage

3.2 Cobweb-Shaped Foundation

Spider's Nest Construction (KSSL) was found in 1976 by Ir.Ryantori and Ir. Sutjipto from ITS and was developed in 1996 in collaboration with experts from the Bandung Institute of Technology. Then, in 2004, PT. Katama Suryabumi was granted an improvement patent with the Patent Number: ID 0018808 as the patent holder and special implementer of the Spider's Nest Construction Foundation; walls below the ground floor; column under ground floor peil; septic tank and absorption; reservoir tank (if required); The KSSL widening of the ground floor area can be configured to serve as a sidewalk or parking area.

When viewed from a technical aspect, the KSSL foundation has the advantage of being a continuous flat plate at the bottom that is stiffened by upright, flat, and high ribs, resulting in a high equivalent thickness with high stiffness and good bearing capacity. The weight is subsequently distributed considerably more broadly and evenly across the surface of the supporting soil layer. Placing

settlement ribs that are deep enough can limit total settlement, protect the soil improvement from negative influences from the surrounding environment, and boost the building's stability against the danger of tilting. These ribs also serve as insulating walls of the soil improvement system, allowing the soil to be compacted to a high density.

From an economic aspect, KSSL technology is environmentally friendly because it only uses a small amount of wood in its implementation, it does not cause noise around it, and the material used is more economical because it consists of 80% soil and 20% reinforced concrete, so the use of building materials is more economical than raft foundations. Aside from that, there will be no folding or lateral buckling effect on the ribs during the KSSL compaction process, causing the soil to become part of the foundation structure. Then, in terms of implementation, it takes a short time because it is basic, labor intensive, and does not require advanced skills; the implementation does not employ heavy equipment and does not disrupt the environment.

3.3 Finite Element Method

Ribs, in addition to plates, sustain the weight on the bottom layer of KSSL pavement. In addition, the ribs give resistance to the effects of lateral stresses. Construction for KSSL has just recently been introduced in Indonesia, and there is no standard formula for estimating the size of this KSSL, thus study is required to discover a tested and engineering-compliant method. The finite element method is utilized for static and free vibration analysis of RC (Reinforced Concrete) structures supported by raft foundations or SNSF in this finite element modeling. Under appropriate loads, this form of foundation structure, as well as the supporting soil, will be assumed to be linear elastic continuum solids. Under appropriate loads, this form of foundation structure, as well as the supporting soil, will be assumed to be linear elastic continuum solids. Many textbooks cover the 3D theory of elasticity in Cartesian coordinates. Displacements along the 3D Cartesian axes x , y , and z will be indicated by the letters u , v , and w . Small elastic stresses are represented by the letters x , y , and z (normal strain) and xy , xz , and yz (shear strain). The energy conjugate stress is indicated by x , y , z (normal strain) and xy , yz , yz as the shear stress in the xy , xz , and yz planes will take into account the material's isotropy. As a result, stress and strain are connected by a 3D linear constitutive equation that is only dependent on the material's Young's modulus E and Poisson's ratio.

In the case of foundations, it is typical to use $\nu = 0.3$ or $\nu = 0.2$ for unreinforced concrete and $\nu = 0$ for reinforced concrete. The E value is between 10000 and 30000 MPa. Although the elastic behavior of soils is very controversial, specialists such as Terzaghi acknowledge elasticity when internal stresses do not exceed one-third of the soil's experimental load-bearing stress capacity. As a result, these factors must be taken into account during analysis and design. The Poisson's ratio of soil is typically between 0.25 and 0.35, whereas Young's modulus is determined by the compressive test, soil type, and foundation. Structures (plates and ribs) can be used in conjunction with 3D solid or 3D shell components. We employed a 4-node solid element with three displacements u , v , and w as degrees of freedom at the nodes (Batoz et Dhatt, 1990). An illustration can be seen in Figure 4.

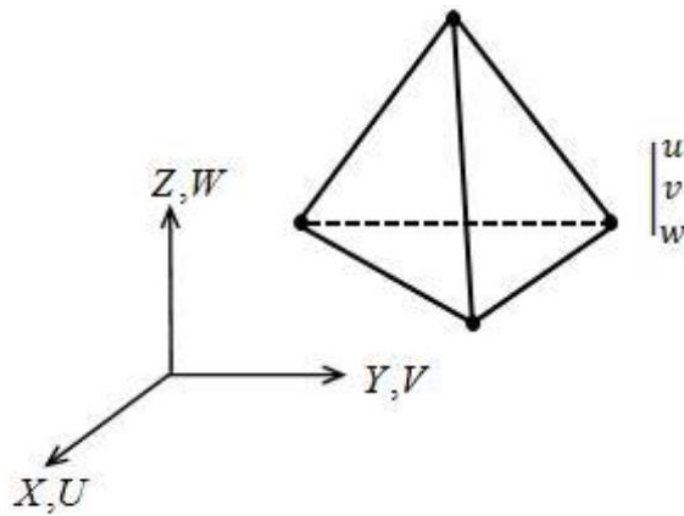


Figure 4. 3D Solid for 4 points (Tetrahedron)

3 and 4 node components from the Optistruct program are utilized for modeling using shell elements. Figure 11 shows that both elements have six degrees of freedom per node, three displacements (u,v,w), and three rotations along the three axes x , y , and z .

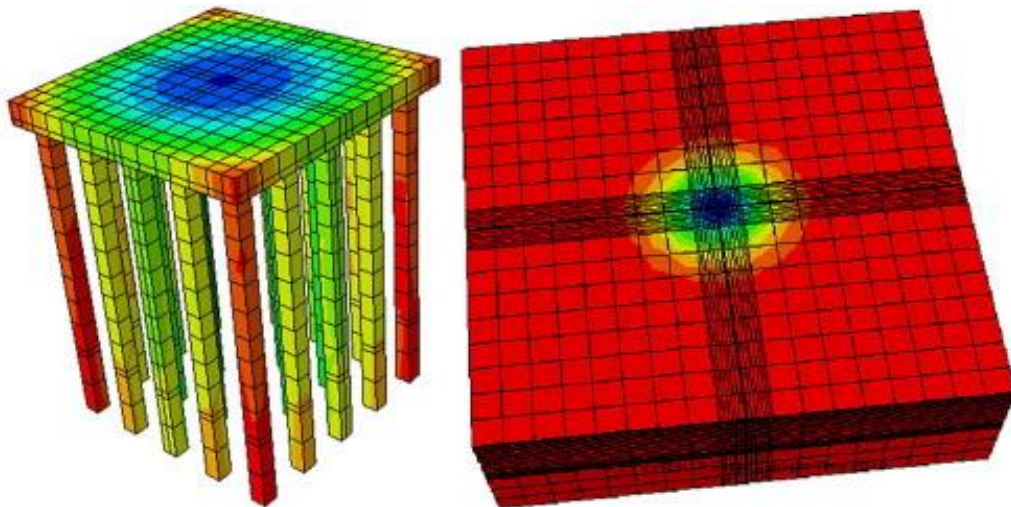


Figure 5. Finite Element Modeling of Foundations and Soil

4. CONCLUSION

The study's results are as follows:

1. Cobweb-Shaped construction can be used as a foundation in road pavement structures, where KSSL is not a stand-alone construction element, but rather a building construction that creates a strong unit.

2. The horizontal resistivity of the KSSL foundation system is an advantage. Horizontal movement can be prevented by side resistance, resulting in high stability.

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