Review on the Rigid Pavement Design for the Tanamori Road in the Labuan Bajo Resort Area of West Manggarai in East Nusa Tenggara Province – Indonesia

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Abstract. Tanamori, West Manggarai, East Nusa Tenggara, as a tourism destination area development in Indonesia needs to be supported by the existence of roads as the main means of its development. The road plan is in an area with heavy terrain so it takes a long transportation time. The limited time for completion of work with severe terrain conditions affects the selection of the appropriate type of pavement to be applied. Based on the location conditions and several previous studies, it is necessary to conduct research to determine the type of pavement that is suitable for use. The two types studied are flexible pavement and rigid pavement. The benchmark of the study is based on technical considerations regarding the advantages and disadvantages of applying this type of road pavement in the field. The results showed that flexible and rigid pavements were possible, but based on the difficulty of implementation and execution of the work, rigid pavements were considered more suitable for construction work time. Rigid pavement structure with pavement with 20 cm thick concrete slabs, with joints. D16 T bar for longitudinal joint reinforcement and D33, 450 mm wooden bar for transverse joint reinforcement.

Keywords: flexible pavement · heavy terrain · rigid pavement · Tanamori road · transportation time

1 Introduction

The function of road pavement is to provide services to transportation facilities, consisting of a layer located between the sub-grade and the wheels of the vehicle. During the service period, it is hoped that no significant damage will occur. The road pavement layer consists of 90–95% aggregate by weight of the pavement mixture, with asphalt or cement binders to form a waterproof pavement. Pavement with asphalt binder is called flexible pavement, and pavement using cement is called rigid pavement. Pavement layers by combining rigid pavement and flexible pavement are called composite pavements [1].

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The selection of the type of pavement requires a technical study so that its use is in accordance with the location where the road is built. Especially concerning the terrain for the transport of certain materials. So that the implementation of the work becomes easy, efficient in terms of cost and processing time and does not forget the existing design criteria [2]. In relation to road function, other considerations such as road class (relation to traffic volume and load), drainage conditions, design life, initial construction costs, ease of maintenance and repair [3]. The plan for the construction of the Tanamori road, West Manggarai, is in an area with tough terrain so it takes a long time to travel. This affects the selection of the appropriate type of pavement to be applied. Based on the location and several previous studies, it is necessary to conduct a study to determine the type of pavement that is suitable for use. Technical considerations regarding the advantages and disadvantages of pavement type applications at work sites are used as a benchmark for the study.

2 Introduction

2.1 Type of Pavement

Road pavement is a layer that is located between the sub-grade layer and the vehicle wheels which functions to provide services to transportation facilities and during the service period it is hoped that no damage will occur. Based on the binding material, road pavement construction is divided into flexible pavement, rigid pavement, and composite pavement.

Flexible pavement is a pavement that uses asphalt as its binding material and the pavement layer is to carry and spread the traffic load to the sub-grade. Rigid pavement is a pavement that uses cement as its binding material, either with or without reinforcement, which is placed on the sub-grade with or without a sub-base layer, and the traffic load is mostly borne by the concrete slab. While composite pavement is rigid pavement combined with flexible pavement, in the form of flexible pavement on rigid pavement or vice versa [4].

2.2 Flexible Pavement Characteristics

There are several factors that affect the quality of flexible pavement, one of which is the compaction temperature of the mixture during the compaction process at the project site. In a project where the mixing site (AMP) is far from the laying and compaction site it will have lower quality than the one near it, because it takes longer to travel to the project site. So, there is a decrease in temperature. Factors that greatly affect the decrease in the temperature of hot mix asphalt are delivery time, delivery distance between AMP and the overlay location, travel time and delays, weather, and density of asphalt covering tarpaulin [5].

The farther the distance to transport the hot asphalt sample, the lower the temperature will be. When the temperature drop is greater, the resultant density of the mixture will be less than the required optimum temperature [6].

2.3 Rigid Pavement Characteristics

Cement concrete pavement is a structure consisting of continuous (non-continuous) cement concrete slabs without or with reinforcement or continuously with reinforcement, located above the sub-base or subgrade without or with an asphalt surface layer. In cement-concrete pavement, the bearing capacity of the pavement is mainly obtained from the concrete slab. The nature, bearing capacity and uniformity of the sub-grade greatly affect the durability and strength of cement-concrete pavements.

The strength of cement concrete must be expressed in terms of the flexural strength of the age 28 days, which is obtained from the test results of beams with three-point loading (ASTM C-78) which is typically around 3–5 MPa (30–50 kg/cm^2). It is recommended that the flexural tensile strength of concrete specified for planning purposes and durability at the age of 28 days should not be less than 4 MPa (40 kg/cm^2).

Concrete mixtures made for cement concrete pavements must have good workability in order to provide ease of work without segregation or bleeding and after the concrete has hardened it meets the criteria for strength, durability, water resistance and driving safety cement-concrete, the bearing capacity of the pavement is mainly obtained from the concrete slab. The nature, bearing capacity and uniformity of the subgrade greatly affect the durability and strength of cement concrete pavements [4].

Rigid pavements have advantages over flexible pavements in terms of lower construction life cycle costs due to minimal maintenance, more durable and stronger, and lower environmental impact. The disadvantages are that the initial costs and construction repairs are quite high, it takes time to be strong enough to pass, it is not suitable for unstable road construction or unsettled utilities, inconvenient (roughness, joints), and glare due to the color of the pavement which tends to white [7][8].

2.4 Reason for Choosing Pavement

Several factors must be considered in choosing the type of pavement [1], as follows:

a. Technical Factor
   Technical factor is the most dominant factor to measure roadworthiness. Technical factors include weather resistance, soil movement resistance and resistance to traffic changes.
b. Non-Technical Factors
   The non-technical factor that affects the feasibility of a road pavement is the maintenance period factor related to the speed or duration of a construction requiring repair.
c. Fund Availability Factor
   The availability of resources is related to the availability of funds. The two non-technical factors indicate that as few maintenances and repairs are carried out as possible, it means that road construction is considered better and the availability of resources, especially funds, is a very decisive factor in determining whether a construction is chosen to be built or not. Because basically funds are always an obstacle to the availability of road construction budgets in Indonesia.

3 Results and Discussion

3.1 Technical Overview of Field Conditions

The position of the pavement is in the embankment and excavation. Figure 1 shows the Typical cross section of the embankment area, and Fig. 2 is the Cross section of the excavation area.

- Flexible pavement material

  a. AC-WC 50 mm
  b. AC-Base 75 mm
  c. Tack coat 0.35 Liter /m2 [9]

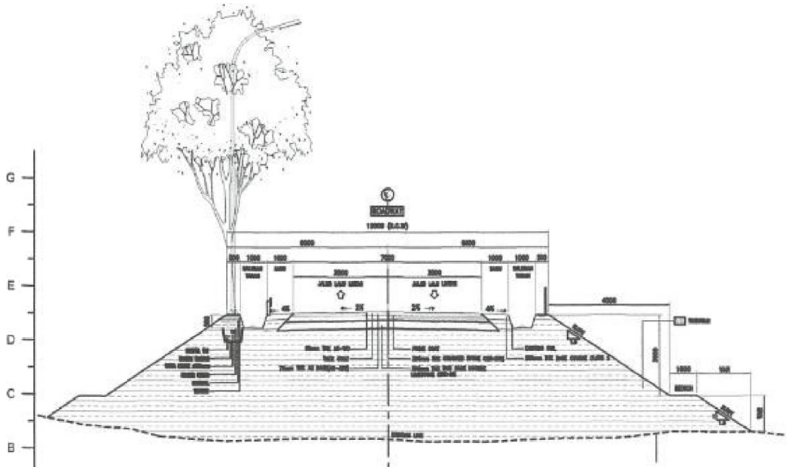

Fig. 1. Typical cross section of the embankment area

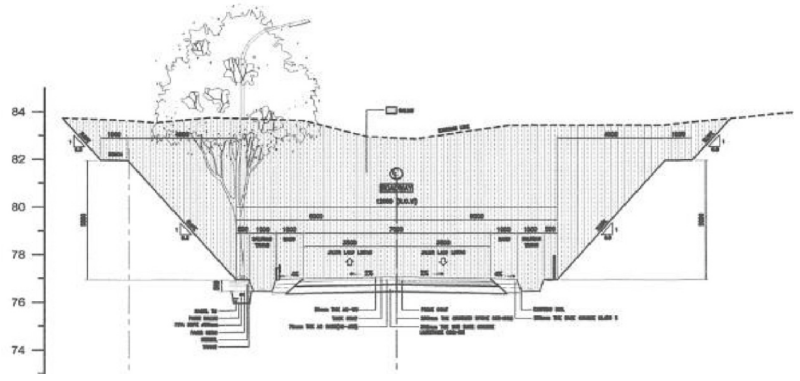

Fig. 2. Cross section of the excavation area

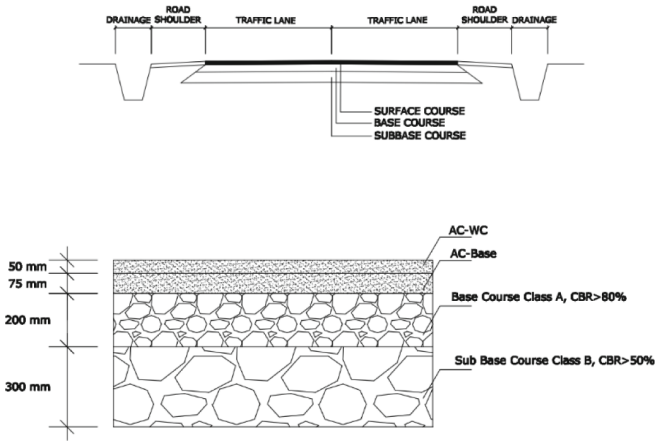

Fig. 3. Structure of flexible pavement layers

d. Prime coat 0.15 Liter/m2
e. Base course Class A (CBR>80%) 200 mm
f. Sub base course Class B (CBR>50%) 300 mm

- Rigid pavement material (concrete)

a. Fc 10 MPa
b. Fc 25 MPa

- Specific gravity of asphalt concrete 2.3 ton/m3 [9]
- Travel time from Asphalt Mixing Plant (AMP) to the job site is 3 h, with difficult terrain and many steep climbs.
- CBR of subgrade based on test results between 3%-30%.

3.2 Flexible Pavement Construction Design

The results of the flexible pavement design for the location of the Tanamori road, West Manggarai are shown in Fig. 3.

The flexible pavement structure is shown in Fig. 3. Based on the type and thickness of the pavement layer, with Eq. (1), the Pavement Thickness Index (ITP) value is 11,325. [10].

$$\text{ITP} = \text{a1.D1} + \text{a2..D2} + \text{a3.D3} + \text{a4.D4} \tag{1}$$

$$\text{ITP} = 0.4.5.0 + 0.35.7.5 + 0.14.20 + 0.13.30 = 11.325$$

where:

a1, a2, a3, a4 is the number of the relative strength of the material, namely:
a1 = AC-WC = 0.40

a2 = AC Base = 0.35
a3 = Base course Class A = 0.14
a4 = Base course Class B = 0.13
D1, D2, D3. D4 is the thickness of the pavement layer, i.e.:
D1 = AC-WC = 50 mm (5.0 cm)
D2 = AC Base = 75 mm (7.5 cm)
D3 = Base course Class A = 200 mm (20 cm)
D4 = Base course Class B = 300 mm (30 cm)

With the value of ITP = 11,325, the road designation is for moderate to heavy traffic. The pavement structure is suitable for subgrade conditions consisting of original soil, excavation and embankment with adequate bearing capacity. However, the high slope of the road in the longitudinal direction makes it difficult to move the compactor and material dropping. It takes about 3 h to transport hot mix asphalt to the job site from AMP.

3.3 Rigid Pavement Construction Design

Based on the results of the analysis of the flexible pavement design, an analysis of the rigid pavement design was carried out. The ability of rigid pavement structures must be more or at least the same as flexible pavements in supporting traffic loads.

The study of the construction strength is carried out based on the rigid pavement planning guidelines, as follows [11]:

a. Analysis of the type and thickness of the foundation
   Foundation with lean concrete (LC), with flexural tensile strength = 10 MPa, with a thickness of 100 mm (10 cm), on subgrade CBR 3% get an effective CBR of 20%.
b. Concrete slab thickness analysis
   Concrete slabs (flexural tensile strength = 25 MPa) with a thickness of 20 cm (200 mm) are joined. The joint distance is 4 meters (4000 mm) in the transverse direction and the longitudinal joint is at the center line of the pavement (see Fig. 5). So the dimensions of the concrete slab are length = 4 meters, width = 3.5 meters, and thickness of 20 cm. Safe against fatigue and erosion. Concrete slab thickness analysis.
c. Joint reinforcement analysis
   Reinforcement between transverse joints (transversals) using D33 dowel length 450 mm. Plain reinforcement is used with one end clamped, and the other end can move freely. While the longitudinal direction (longitudinal) connection uses screw reinforcement, clamped, with T Bar D16 and a length of 750 mm, meets the requirements [12].

The rigid pavement design for the Tanamori road is shown in Figs. 4 and 5.

The results of the analysis show that the rigid pavement construction design can be used, and is safe if the materials and implementation methods are in accordance with the specified procedures.

Based on field conditions, where rigid pavement work is more ready because it is supported by equipment and concrete mixing units. However, with subgrade which

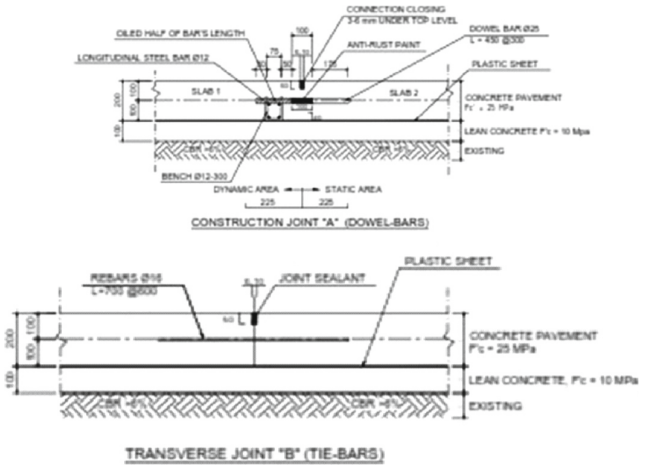

Fig. 4. The structure of rigid pavement layers

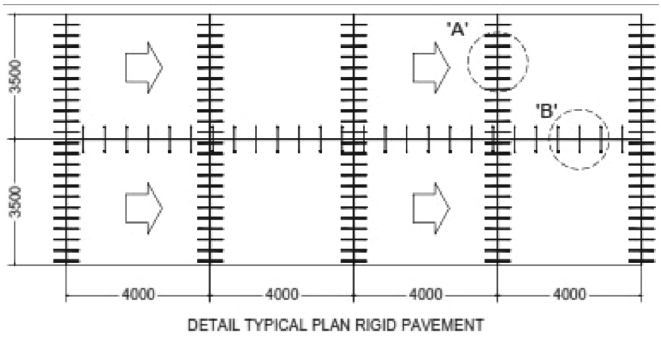

Fig. 5. Detail typical plan rigid pavement.

generally has good bearing capacity (high average CBR), flexible pavement is more suitable.

3.4 Comparative Analysis of the Use of Flexible and Rigid Pavement Construction Design

Analysis of the selection of the use of rigid pavement types with flexible pavement, to be applied at the Tanamori road location based on the travel time from the AMP (Asphalt Mixing Plan) to the job site is 3 h. Estimated decrease in temperature of 3O per hour, then there is a decrease in temperature of 12O. This will make the temperature of the asphalt mixture when it arrives at the site already below the softening point (does not meet requirements for compaction).

The large longitudinal slope makes it difficult for maximum compaction of the asphalt mixture. Besides the terrain conditions (steep slope), the compactor also has difficulty maneuvering.

Concrete mixtures made for cement concrete pavements must have good workability in order to provide ease of work without segregation or bleeding and after the concrete has hardened it meets the criteria for strength, durability, water resistance and driving safety cement-concrete, the bearing capacity of the pavement is mainly obtained from the concrete slab. The nature, bearing capacity and uniformity of the subgrade greatly affect the durability and strength of cement concrete pavements [4].

The road being built is a new road to serve tourist area activities, so it is not classified as heavy traffic. However, during construction, heavy vehicles will pass by to transport materials. In general, the subgrade has a good bearing capacity making it suitable for flexible pavement. However, in terms of ease of completion of work (related to time), the use of rigid pavement in this location is more suitable.

4 Conclusions

Based on the results of the analysis and discussion, the conclusions of this study are:

a. The application of flexible and rigid pavements is possible at the study site, but based on the difficulty of the terrain and the execution of the work, rigid pavements are considered more suitable in relation to the construction time.
b. The type of rigid pavement structure used is the Join Concrete Pavement type with a concrete slab thickness of 20 cm. Longitudinal joint reinforcement with T Bar D16 and transverse joint reinforcement with Dowel length D33 450 mm.

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