

Study on Main Technique in Expansion Project of Expressway

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Abstract: Due to the constraints on the socio-economic, technology and knowledge during the construction time; the early construction of China's expressway is focus on dual-way four lane, with lower standard. Recently, the rapid economic growth of China has catalyst the rapid growth on the demand of transportation facility, far exceeding than the forecasted traffic volume obtained through transportation planning project. This resulted the increasing of traffic volume on the transport facility built early years, the stuck of the traffic flow and the decreasing on the level of service. This article takes the expansion project of Guangxi Coastal Expressway as case study; investigate on how to optimize the expansion program. The article could be used as a reference in achieving convenience transport facilities, from both aspect of theoretical and practical.

Key words: Expressway, Expansion project, Main technique

Introduction

The expressway that in used in China that was built during the 20th century of the 1980s and 1990s are all required an expansion works to be done to improve the level of service currently. Due to the difference between the construction technique and technical specifications adopted during modern and past, the reconstruction of the old linear pathway need to be adjusted to fit with the latest regulatory requirement. This article used the expansion project of Guangxi Coastal Expressway as case study, based on the consideration of the bridge elevation and construction works of transport facility to investigate and provide the corresponding measures and methods on expansion mode, optimization of lining and technical issues of the connection between the existing and new constructed bridge.

1. Project Overview

The sectional of Coastal Expressway from Qinzhou to Beihai was designed on May 1996, construction of embankment, culvert and etc. was started on January 1998, pavement was constructed on September 1999, followed with a series of installations works on transport and traffic facility, was finally in commenced on October 2000, operated for more than 10 years till date. The original road section was design between year 1995 to 1996, was referred to "Highway

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Engineering Standard” (JTJ01-88), “Road Design and Specification” (JTJ011-1994), the central divider was anti-crush reinforced concrete barrier, design speed is 120 km/hr, roadbed width of 28 m (Section K2085+400~K2093+388 is 33 m), all line was concrete pavement, was in operate for years, the main concern for current expansion work are:

1.1 Increasing of traffic volume, but not fully saturated, is the best time to expand

To reduce the traffic impact during the construction and social impact, expansion work on expressway should come with a comprehensive analysis on the traffic network and its carrying capacity, traffic flow during construction period and traffic impact; to plan the reasonable construction timing. The expansion project that maintains the continuity of traffic will normally reduce the original level of service to a lower two grade to ensure the quality of highway in providing the basic service. According to the traffic volume data collected for the Guangxi Highway Authority, the current traffic volume for the largest section of the Guangxi Coastal Highway is 1200 pcu/day, which is still the level of service A for four carriageways with better driving comfortability, lesser driving interference and lower accident rate. If the expansion work was executed now, the accessibility of both carriageways was assure, partial bridge segment could use half-close construction which minimize the influence to the whole lining. Meantime, the growth of traffic volume is far exceeded the expectation based on the traffic 20 years of operational experience of expressway in China; some of the four carriageways was unable to support the traffic demand. With refer to this case, numerous of unforeseen factors on the growth of traffic volume will appears due to the rapid growth of Northern China-ASEAN Free Trade Economic Zone. The traffic density of four carriageways will be saturated in coming three to five years. At that time, the construction cost and difficulties will definitely increasing. Thus, now is the best time to conduct the expansion project.

1.2 Higher standard of existing project, lesser constraint, better condition for expansion

Design speed: the design speed of existing road is 120 km/hr, which is the maximum value of current standard. From the fitting result of vertical parameter, the standard of existing road is much higher, with a minimum horizontal radius of 1500m , the maximum longitudinal line is 2.71%, which could be fully utilized without much adjustment. The width of roadbed: the width of roadbed for existing road reached 28 m (Section K2085+400~K2093+388 is 33m), unilateral section required less widening work, existing road provide smooth traffic condition during future construction work. Road surface: based on the investigation, the whole road lining was decided to use “Replacement of concrete pavement with asphalt pavement”. Town planning and land acquisition and resettlement: this project has no conflict related with the urban planning. With the previous proper planning, there is a reservation land of 8 carriageways at both side of the road, this reduced the issue of land acquisition and resettlement. Railway crossing: there is one railway crossing with this project, which is Chinkong Railway(Qinzhou-Kongzhi Railway),the space for the expansion project is clear for the placement of railway crossing, coordination is not difficult. Runoff: : based on the investigation, the existing storm drainage could be maintained according to standard, only the existing bridge structure and span required to be strengthening and widened. Water, cultural, scenery and mineral: there is no large constraint, without any tunnel and special bridge structure. The largest bridge structure is Qinjiang Bridge, with existing design of 7-40 m, the highest pier of 20 m, the strengthening and connection work is less difficult. As conclusion, there is not must constraint for this expansion project, the condition for the expansion is good.

2. Main Problems

2.1 Existing divider required rebuild

The existing divider is reinforcement concrete strip wall,without green element, is not fulfill the standard, poor appearance, ease to cause tiredness to driver, require to be rebuild with divider with green element.

2.2 Upgrade issue of road ramp along the road

Northern coastal economic zone as one of the main latest western development projects, the urban development along the roadway and development of road network are rapidly evolve. Based on preliminary investigation, local government suggested the basic requirement for the upgrading of expansion project on expressway. The proposed expansion project must be economical, reasonable, and feasible; to ensure the local financial and construction development could be coordinated.

2.3 Roadbed

Some of the existing roadway is the connection of cut and fill, half cut and half fill, poor soil condition; which is instable, settled and reformed, causing the brokage, subsidence, void and dislocation of the roadbed. The slope of existing road is stable, without any significance cracking, but the issues are poor flatness of slope surface, loose fill, serious erosion on slope surface, loose and missing slope protection. The subsoil on slope comprise of dense bush, low shrubs, discarded rubbish and slag, resulting in poor drainage and rainwater infiltration.

2.4 Road surface

With the increment of traffic volume, the problem of overloading of vehicle is serious, causing the damages to the existing concrete pavement road, low driving comfortability and level of service. Based on the preliminary investigation, the main issues are: broken plate, vertical and horizontal cracking, slabs fracture and dislocation, shrinkage (expansion) of joint, damage of repair and etc., which yet to be treated.

2.5 Culvert

The authority commented based on the knowledge of existing bridge that the small bridge has no scuppers, causing the ratining of surface on the road surface. Some of the scuppers were blocked by silt and grass, resulting in poor drainage. The bridge over the water has no water gauge, is inconvenient to observe the water depth. The bridge should consider on own safety factor, required extra anti-crash accessory.

3. Overall design

This project is the expansion work of existing road, the existing design speed is 120 km/hr, Section K2085+400~K2093+388 is six carriageways while Section K2093+388~K2126+277 is four carriageways, the width of roadbed is 33.5m and 28m respectively, both required to be widened to two-way eight carriageways with the width of 42m. There are many features along the project such as bridges, culverts, interchanges, separate interchanges. Some section of the road segment is soft soil and poor soil condition.

3.1 Overall design principles

3.1.1 Based on reference, according to specific case study

Using the reference of local and international expansion project of expressway, especially that basic condition is similar to Guangxi Coastal Highway expansion project; to adopt their successful experience and advance idea. The design principles, problems and technical issues faced during construction and each professional method in expanding the expressway could be compared and referred.

3.1.2 Full utilize the reasonable technique in expanding the transport facility based on the existing traffic feature

By properly handle the relationship between global and local, long and short terms, combining the considerations of geography, geology, construction material and other into the analysis to select the most appropriate alternatives that could minimize the influence to the existing accessible of expressway, reduce land acquisition, reduce demolition and

lower capital cost but better technical aspect.

3.1.3 According to land, adopt the reasonable and significance construction technique and method

The information of the construction design, method and maintenance should be gathered for the section of Guangxi Coastal from Qingzhou to Beihai, to understand each of the issues and problems that was faced and respective mitigation and maintenance measures so that conclusive expansion project that is reasonable in term of the technique and design could be proposed based on local site effect.

3.1.4 Consideration on transportation system

The design plan must be beneficial to the transportation system, increase the level of service. The expansion project of the expressway must obtain the suitable transportation system in order to increase the level of service, the selection of the alternative must consider on the maintenance issue and the safety factor of the transportation system. The planning of the arrangement of the construction work, construction manpower and construction period must be able to shorten the construction duration. By compare throughout, the alternative of the construction duration could be reasonably under control, to minimize the disturb on the existing transportation network.

3.2 Design of roadbed

3.2.1 Normal roadbed

1) The overall design of roadbed should be investigated throughout based on natural aspect such as geotechnical, cultural, geographical and metrological aspect, by gathered the original construction drawing, as built drawing and existing roadbed design drawing of maintenance work, assessment should be based on the existing road to provide efficient overall design. 2) Ensure the effectiveness drainage of roadbed and road surface. 3) Design of roadbed should minimize the land acquisition and resettlement. 4) Should remain the financial principles of occupying farmland, to ensure the quality and economy. The resulting excavation work should be reducing as much as possible. 5) The protection of the slope should be the first priority, soil strengthening as the basis, green concept as the whole. The protection work of the embankment should in accordance with the climate, construction site condition and material source, select the economical and reasonable but attractive and practical method, the planting of the grass mat under the stable slope condition, will minimize the volume of soil work.

3.2.2 Special roadbed

1) Soft soil

This project across the paddy field which is under the water in long term, forming soft soil layer, when the soft soil layer thickness is smaller than 3m, it is recommended to use the method of gravel dredging replacement. Requirement is existing roadbed settlement should be $\leq 3\text{cm}$, horizontal slope roadbed increment should $\leq 0.5\%$.

2) Section with runoff and existing road with evaporation pond

Culvert of existing road with ponding runoff or with evaporation pond requires dredging drainage treatment, filled with gravel. After the filling, the evaporation pond at the existing road were dredging for 2.0 m height to reinforced by rolling impact.

3.2.3 Design of roadbed slope

1) Road section with normal fill slope height $H \leq 4.0\text{m}$ should use bush+plant as protection; road section with slope height $H \geq 4\text{m}$, the upper 4.0m of road bed should use bush+plant as protection, lower 4.0m should use herringbone grass protection. 2) The sectional road at coastal and bridge pier will eroded by water or river should use M7.5mortar slope pavement as protection; road section which cross the river or along the river use C25 precast hexagonal solid block protection, normal pier use C25 precast hexagonal solid block protection with grass. This project has lesser road section under saturation, normally use the precast hexagonal solid block 3) With the consideration of land acquisition and safety, the setting of retaining wall for some of the road in this project was decided to be shoulder wall

with counter weight retaining wall, material is C20 in-situ concrete.

3.3 Design of road surface

Based on the information of condition, road grade, land use, material, weather, climate and geology that gathered from original construction drawing, as built drawing and existing roadbed design drawing of maintenance work, the design of road surface was done with referred to local site experience which will beneficial on maintenance, selection of material, construction work and material reuse. The main principle of the road surface design are: under the overall and reasonable assessment of the existing road, in fulfilling the annual operation condition of the widened expressway, select the most reusable alternatives to increase the saving of material and the effect of environment friendly condition. The expanded road surface should able to achieve high standard: based on the travel condition of each carriageway, the design of road surface for each lane should have certain safety allowances and good resistance to high temperature and water damage. The reuse of material of the structure of the existing road surface should be considered, the expansion of the road should also considering the compatibility with the roadbed, the choosing of the best alternatives should have technical and financial prospective. The structure of the new road should have a merging with the structure of the existing road, to reduce the problem of lateral cracking at the connection, also to study new method in connecting existing and new road.

3.4 Rebuild of central divider

Due that the existing central divider is using the reinforcement concrete, is inconvenience with regards to appearance and safety, and should be change to central divider with green concept. Central divider located at the center of road, the subsoil is very shallow, with unconducive driving environment all year, high wind speed, serious pollution, high temperature during summer, is bad living environment to plant. Thus, the selection of plant should firstly consider on the safety of operation function, ensure the effect of glare shading, to achieve the aim of sustainable design; secondly to consider on one time investment and future maintenance; thirdly with compromise to both prior conditions, take note on the effect of appearance, ensure evergreen. The selection of the species of plant should suitable to local condition, soil condition, slow-growing and strain-resistant trees and shrubs.

3.5 Drainage of roadbed and road surface

3.5.1 Drainage of roadbed

The drainage of roadbed consist of drains, ditches, drainage ditches, rapid tanks, sewer and natural rivers. The water was usually drained into the culvert and river, when it meet with the drainage outlet, rapid grooves was used to drain it out. Embankment toe berm was set as 60×60cm size M7.5 mortar rubble rectangular gutter. Embankment head berm was set as M7.5 mortar rubble rectangular gutter, the cover of ditches, is allow to use shallow dish gutter. The drainage ditches at the hillside zoning (fixed at 5 m outside the larger section of the top of the hillside catchment area, usually is 50×50cm rectangular groove), platform drainage ditches (fixed at platform on the cut slope, dimension is 40×30cm trapezoidal groove) two type, drainage ditches outlet section is provided at a steeper water tank or water drop.

3.5.2 Runoff of road surface

Decentralised drainage pattern that was used as the drainage of road surface, the water run smoothly to the overflow drain for embankment height less than 4 m, the water run rapidly to the overflow drain for embankment height more than 4 . To drain out the runoff at the side of the main line, longitudinal drains, sump and lateral drain were use at the side of the road, which is through the connection of the lateral grooves drain outlet.

Conclusion

Construction of the expressway is bound to affect the traffic , the traffic of the whole road will be affected, this will definitely causing the economy loss, effective strategies is need by construction contractor to minimize the

inconvenience caused to the traffic flow. Based on the analysis of this article can be concluded that the design of the traffic is vital important. Reasonable design could largely minimize the pressure causing due to construction work. The investigation in future must be extend in this direction, making the design of expansion of expressway project more scientific, reasonable and feasible.

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