APPLICATION OF VALUE ENGINEERING AND CARBON REDUCTION(GREEN VALUE ENGINEERING) IN THE TAIWAN ANKENG LIGHT RAIL

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BIOGRAPHY:

Cheng-An Lee is a professional expert and leader with 24 years of experience in overseeing the lines planning, construction, regulation, running and maintenance of MRT system. He holds a bachelor degree in Civil Engineering and a master degree in Power Mechanical Engineering. Moreover he is currently the Acting Commissioner of the Department of Rapid Transit Systems, New Taipei City Government.

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Chien-Ming Lai is a AVS and professional expert with 15 years of experience in the designing of MRT system. He holds a master degree in Civil Engineering . Further he is currently Project Manager of the Sinotech Engineering Consultats,LTD..

ABSTRACT

Since 1987, Taiwan track project has formally promoted the value engineering technology. During that period, the techniques were to transfer and cultivate. Until now, Government departments have been widely utilized this technology to apply various projects. Recently, Taiwan public works actively promote the construction goal of the humanism, high quality, and sustainability. By means of value engineering techniques, the real requirements guide the design to achieve the objective of saving and sustainability.

Recently, New Taipei City Government adopted green value engineering techniques to lead the design in promoting Ankeng light rail based on the comprehensive plan. Finally, the six proposals were submitted and accepted. A total saving cost of project is 251 million NTD and carbon emission reduction is 5,323 metric tons. In this paper, the concept, research method, analysis processes, carbon emission calculation, and the results of the combination of value engineering and carbon reduction technology (green value engineering) are represented. The relevant experiences could be referred to Value Engineering administrators in the future.

INTRODUCTION

Man-made carbon dioxide and other greenhouse gas emissions are the main causes of global warming. Since the third United Nations Framework Convention on Climate Change (UNFCCC) hold in Kyoto, Japan on 1997 has drawn Control Agreement, all major carbon emission country are lack of determination on global warming even though Kyoto Protocol has extended until the end of 2020.

This paper discusses Ankeng LRT Value Engineering Assessment, and the owner of Ankeng LRT is New Taipei City Government. The Ankeng Line alignment is 7.67 kilometers in length, with 4 at-grade stations, 5 elevated stations and a depot, as shown in Figure 1. Starting from the depot located at the intersection of Antai Road and Anyi Road, the project route extends north at-grade along the median of Anyi Road with stations on median at-grade. Station K1 is located near the entrance of Radiant & Sweet Community. Other at-grade stations include Station K2 at Rose Road, Station K3 west of Qiaoxin Road, Station K4 west of Chezi Road, Station K5 east of Anzhong Road. The alignment is depressed to sub-grade after passing Dayuan Camp. It extends along Anyi Road and turns along Anhe Branch Road, and subsequently climbs up to cross Ankang Road on an elevated structure. Station K6 is an elevated station near the intersection of Anhe and Ankang Roads. The alignment continues northward on a viaduct along Anhe Road, with Station K7 located at Taiwan Malt Factory. It overpasses Freeway 3 and the ramp to ZhongAn Bridge, and turns east, with Station K8 located by the office complex of Water Resources Agency. It then follows a planned road and turns eastward on the south side of Jian Mount., flyover Huanho Expressway of Taipei County and Xindian Creek to reach Shisizhang Road in Xindian, with Station Y7 of the Circular Line.

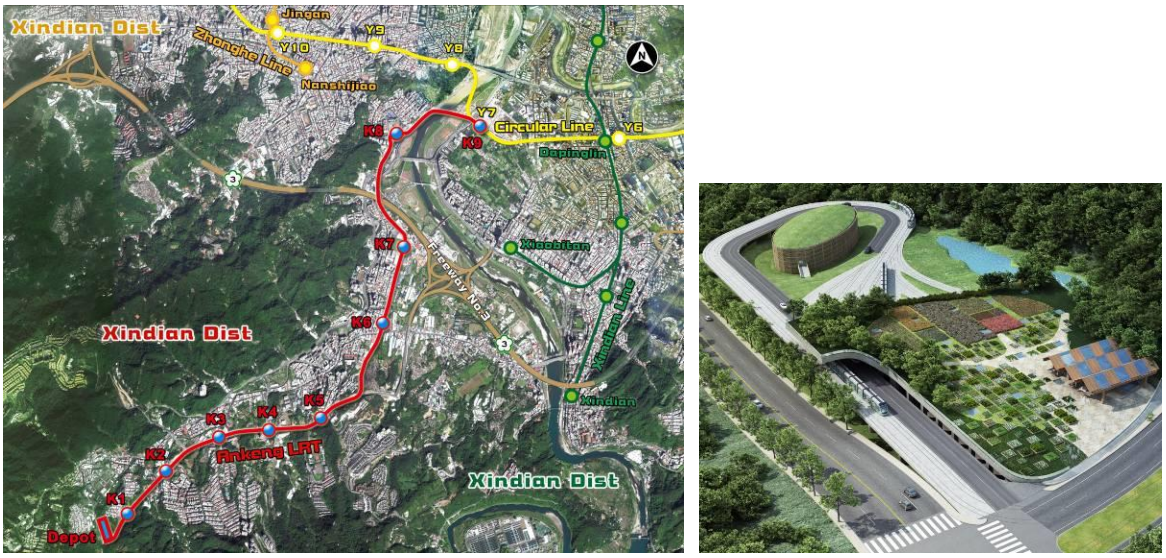

Figure 1: The Scope of Ankeng Light Rail

CONCEPT OF THE COMBINATION OF VALUE ENGINEERING AND CARBON REDUCTION TECHNOLOGY (GREEN VALUE ENGINEERING)

The value engineering technology, an effective method of cost saving, has been widely applied in various stages of the project. In recent years, the policies of saving energy, reducing carbon emissions, and sustainable construction have been continually enforced. The value engineering is not only utilized in the saving purposes, but also in the aspect of green building and carbon emission calculation such as Taiwan

Green Building Nine Evaluation Index System (EEWH), United States Green Building Rating System (LEED), etc.. Recently, the practices of value engineering have been executed in domestic and international area. In the implementation process, the project costs and carbon emissions of the related activities were estimated at the same time. Meanwhile, the feasible solutions have been evaluated. In conclusion, the benefits of green value engineering are not only saving costs but also to enhance the function performance,reduce the environmental impact, and fulfill the objective of sustainable construction.

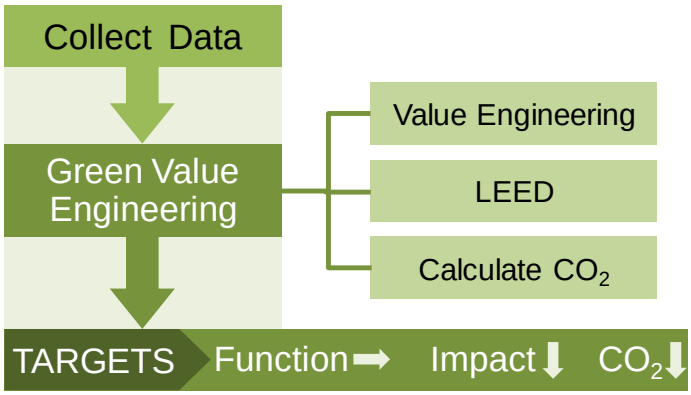

Figure 2: The Concept of Green Value Engineering

METHODOLOGY OF THE COMBINATION OF VALUE ENGINEERING AND CARBON REDUCTION TECHONOLOGY (GREEN VALUE ENGINEERING)

The value engineering is the organized and systematic research procedures that focus on the system functions. The green value engineering is further to add carbon emission calculation without affecting the initial project functions. Based on the Cost Model to define the unnecessary costs and CO2 Model to realize the potential carbon emissions of the relevant activities, the solution with lower construction costs and huge carbon reduction could be selected in accordance with researching on construction activities with larger carbon emissions.

ANALYSIS RESULTS OF THE COMBINATION OF VALUE ENGINEERING AND CARBON REDUCTION TECHONOLOGY (GREEN VALUE ENGINEERING)

After discussion, review, modification and conception integration, 6 VE proposed cases will be approved by the owner, The VE assessment will save $251,000,000 NTD and educe 5,323 metric tons of carbon emissions.6 VE assessment results are, briefly described as below

CASE-A. Reduce Platform and Roof Length by Train Requirement

The rolling stock of Ankeng LRT is the same as that of Danhai LRT (265 Passengers/Train). The train is assembled by 5 cars and the length of train is 34.46m. According to vehicle data, the platform length can be reduced from 49m to 39m, and the platform roof can be adjusted from 39m to 27m. The VE assessment will save $16,142,850 NTD and reduce 41.30 metric tons of carbon emissions.

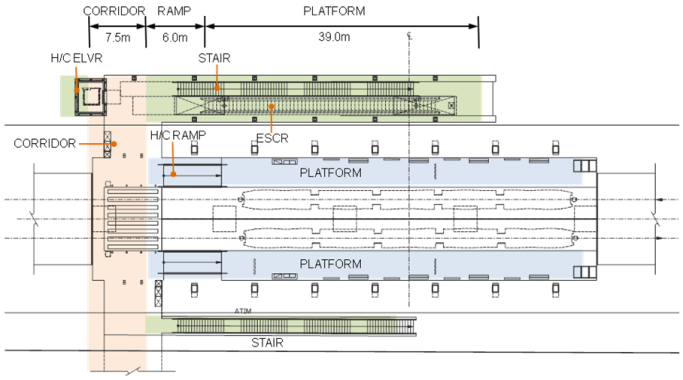

Figure 3: The Platform Length of Elevated Station decrease to 39.0m(Recommendation)

Figure 4: The Roof Length of Ground Station decrease to 27.0m(Recommendation)

CASE-B Depot Layout Combined with the Surrounding Environment

The depot located at the intersection of Antai Road and Anyi Road, and the area of depot is about 3.8 ha. On geographical environment, the overall terrain elevation all the way from the southern part depot near AN 1st RD (85m elevation) down to the north part depot An Tai RD (60m elevation), east side of depot is steep hill, west side of depot near Wuchong River tributary valleys, the depot base also has a small stream crossing from north to south, the terrain elevation and ecological appearance diversity. Original planning design, the depot is two level, the upper is master repair plant, the lower level is storage plant, the planning design will construct an artificial platform for deport. The upper level depot elevation is 85m to 97m; the elevation of depot surrounding area is 60m, nearly 40m elevation drop between depot and surrounding area. The recommendation case considers the overall project cost, environmental impact of ecology landscape and other factors, depot will construct single level, the elevation of depot will fall between73m and 85m, and this design without artificial platform can reduce construction costs, the overall environmental impact and landscape impact. The recommendation design case is based on Agropolis concept, which match Ankeng area unique natural environment and the development process, provides edible landscape, a special opportunity for self-sufficiency of low-carbon agricultural production. Consideration the depot is sitting near the Erbazi Botanical Garden, and Ankeng farm of National Taiwan

University, unique Agropolis energy to build this project depot will become a core base of Agropolis. The VE assessment will save $65,873,375 NTD and reduce 1574.00 metric tons of carbon emissions.

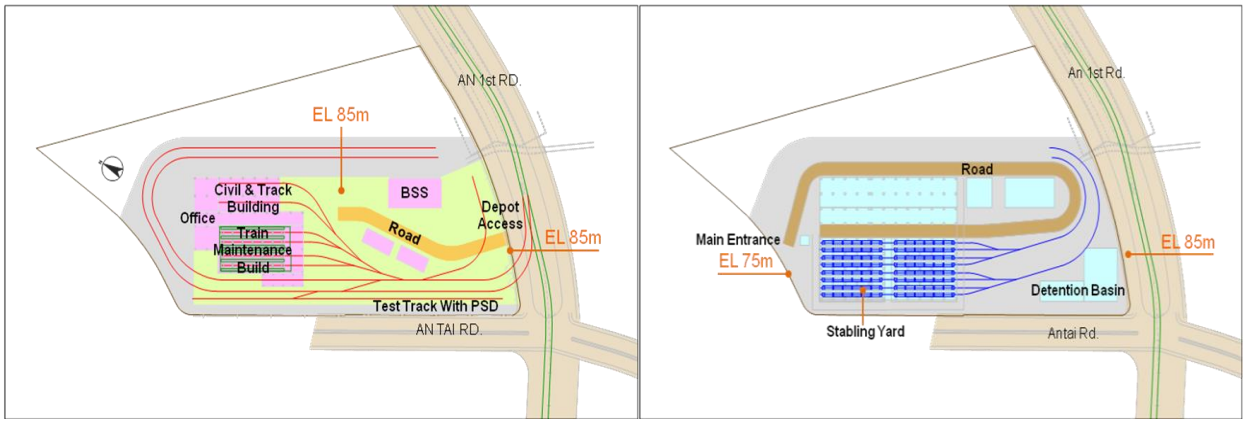

Figure 5: The Light Rail Depot Plane Space(Two Floors)(Original)

Figure 6: The Light Rail Depot plane space(One Floor)(Recommendation)

CASE-C Three-span Cantilever Bridge Replace Single Span Bridge base on Alignment Adjusted of Wuchong Creek

Original planning design Ankeng LRT alignment locate at the middle of Amhoa RD., but consider the LRT estate across Freeway 3 will not expropriation, Amhoa RD cannot maintain 20m wide road, the use of a large span bridge across the Wuchong Creek with 5m pier of bridge will impact Amhoa RD layout. The recommendation design case adjusted alignment toward to downstream Wuchong Creek and parallel Wazzi Bridge, and 3-span continuous prestressed cantilever bridge will use for Wuchong Creek bridge. The main span is 97m, and the bridge piers locate at high river embankment. The VE assessment will save $76,950,000 NTD and reduce 482.77 metric tons of carbon emissions.

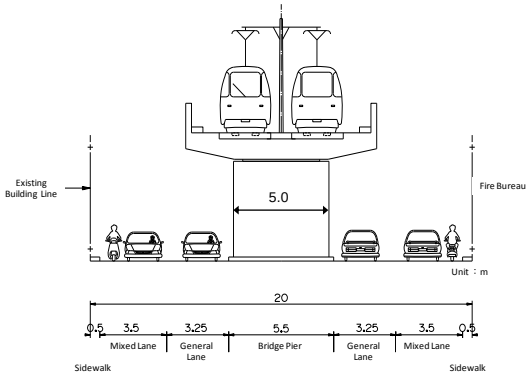

Figure 7: The Column of Single Span Bridge(Size=5.5m)(Original)

Figure 8: The Column of Three span Bridge (Size=3.8m)(Recommendation)

CASE-D Elevated standard U-shaped Girder Bridge Change to Box Girder Bridge

The total viaduct length of Ankeng LRT is 4020m, standard bridge length which means span under 30m is 1,710m(57 spans), representing 42.5% of total length of viaduct bridges. Original planning design the type of standard bridge is a prestressed concrete U shape girder for a LRT rail and full-span lifting construction method is used to installation. However, roads at Ankeng area are narrow after K8 station, beam carriers are different to transport U shape girder. The prestressed concrete U shape girder reduces from 57 spans to 50 spans. Base on economic considerations,the recommendation design case applied 57 standard box-type bridge girders and advancing shoring method or cast in place method to installation. The VE assessment will save $20,790,000 NTD and reduce 1374.03 metric tons of carbon emissions.

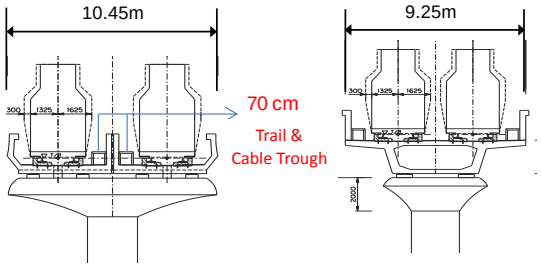

Figure 9: U Girder(Original) and Box Girder(Recommendation) Comparison Chart

CASE-E Long-span Xindian Creek Bridge Research and Analysis

Original planning design ,the use of long-span bridge with two piers,is to avoid affecting the Xindian Creek hydraulic analysis behavior, but the bridge is not wide enough; it cannot create transverse arch effect and affect the formation of displacement.The recommendation design case replace basket handle bridge with pararel bridge, the same function with the original program, but it can reduce the displacement generated by the wind. The VE assessment will save $12,455,000 NTD but cannot reduce carbon emissions.

Figure10: Basket Handle Type (Original) and Pararel Type (Recommendation) Comparison Chart

CASE-F Depot Entry and Exit Rail Foundation Review

Original planning design for entry and exit depot bridge is pile foundation, the pile cap dimension is 18mx18mx4m, and pile diameter is 2m with 16 whole casing piles. Base on geological survey information, the geological formation is sandstone and well standing condition during excavation. The recommendation design case replaces pile foundation with 10m diameter well foundation. The VE assessment will save $58,797,505 NTD and reduce 1851.16 metric tons of carbon emissions.

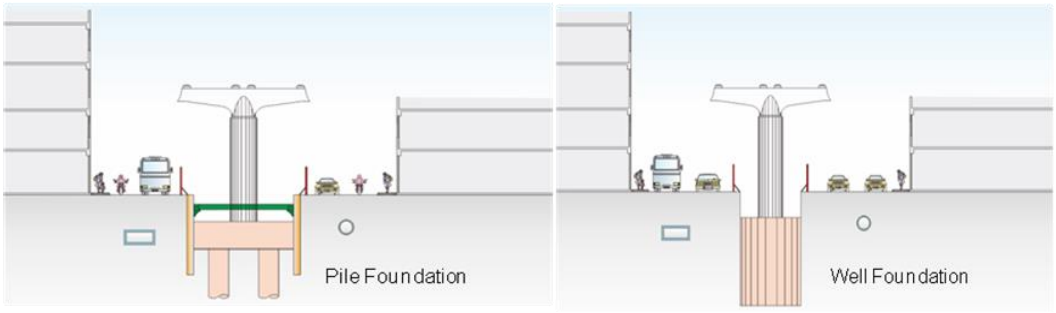

Figure 8: Pile Foundation(Original) and Well Foundation(Recommendation) Comparison Chart

DESCRIPTION AND RESULT OF CARBON EMISSION REDUCTION ASSESMENT TECHNIQUES

The calculation generally adopted for assessing the greenhouse gas emissions is emission factor method. The formula is that greenhouse gas emissions (carbon dioxide equivalent) = Σ emission intensity (carbon emissions activities, such as oil, electricity, water, and the amount of material used) × carbon emission coefficient (unit activity of greenhouse gas emissions, expressed in carbon dioxide equivalent) .In the

planning, basic design, and detailed design phase of the project, the carbon emissions based on the construction activities are estimated according to the Unit Price Analysis Table of labor, equipment, materials, and other miscellaneous items. In the Planning and basic design stage, the detailed quantities of main construction activities are provided. The remaining items are approximately breakdown to length, area, or lump sum. The total budget for project is illustrated by the summary sheets and detail sheets and not by detailed analysis of the unit price. Therefore, the total carbon emissions are evaluated by unit price analysis of detailed design from the similar character or scale construction.The case utilized the mentioned formula to estimate the carbon emissions of relevant construction activities. Through the green value engineering techniques and evaluations, the results are shown in Table 1.

Tabie 1 The Achievement of Carbon Reduction and Cost Reduction

Item	Carbon Reduction(t)	Cost Reduction(NTD)
Reduce platform and roof length by train requirement	41.30	16,142,850
Depot layout combined with the surrounding environment	1574.00	65,873,375
Three-span cantilever bridge replace single span bridge base on alignment adjusted of Wuchong Creek	482.77	76,950,000
Elevated standard U-shaped girder bridge change to box girder bridge	1374.03	20,790,000
Long-span Xindian Creek bridge research and analysis	-	12,455,000
Depot entry and exit rail foundation review	1851.16	58,797,505
SUM	5323.26	251,008,730

CONCLUSIONS AND RECOMMENDATIONS

Due to the issue of global carbon reduction has persistently got much attention, the carbon reduction of public works has been listed as one of the most important topics. In 21st century, rail system is the most environmentally friendly green transportation tool. The relevant construction methods may result in higher carbon emissions in the urban area. How to combine the track construction and carbon emission reduction will become the major subject in the future. Based on the concept of carbon footprint, the amount of carbon emissions for the related MRT construction activities was calculated. Then, the solution of the lower construction costs and huge carbon emission reduction should be selected and confirmed by means of value engineering techniques. Finally, it decreased the construction costs and diminished the carbon emissions in order to achieve the goal of carbon reduction and green environmental protection. Moreover, the proposed methodology promotes the combination of value engineering techniques and carbon reduction to decrease the impact of the project on earth.

REFERENCES

Institute of Transportation, Ministry of Transportation and Communications. (2012). The Research on Carbon Emission Model and Benefit Analysis for Transport Engineering.