

Design Method for Road Reconstruction and Expansion

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Abstract: This article analyzes the method for designing routes in road reconstruction and expansion projects, using an actual engineering project as an example. This includes an overview of a specific road reconstruction and expansion project, an analysis of the preexisting road, the basic principles of the design road project, and an analysis of the design methods and steps. This study aims to offer some guidance for road reconstruction and expansion design.

Keywords: Road engineering; Reconstruction and expansion; Line design; Design principles

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1. Introduction

With the continuous development of the modern highway transportation industry, traffic needs are becoming increasingly difficult to be met by pre-existing roads. Therefore, the engineering department needs to carry out reconstruction and expansion of the roads. Route design is a key aspect in the specific reconstruction and expansion process. Based on this, the designer should take reasonable methods and steps to design the route based on the specific project overview, reconstruction and expansion needs, and the actual conditions of the road.

2. Project overview

The total length of the highway project reconstruction and expansion section studied in this paper is 6.987 km. The road surface is an asphalt concrete structure, and the cross-section form consists of 4.5 m curb strips with 7.5 m and 6.5 m central separation strips, following the first-class highway engineering standard. For this reconstruction, it was built into a two-way, four-lane format with a road shoulder width of 31.5 m and an asphalt concrete structure to meet the requirements of the road project. After reconstruction and expansion, the total length will be 7.458 km and the road will have 5 crossovers. This article analyzes the route design method in the road reconstruction and expansion project.

3. Analysis of current road

The designer and relevant staff evaluated the current status of the road, identified its problems and bottlenecks, and analyzed the traffic flow. The following are the main analysis results of the reconstruction and expansion project of this road.

3.1. Assessment of the current status of the road

When evaluating the current status of the road for reconstruction and expansion, the designer adopted the following evaluation methods:

- (1) Pavement type and materials are evaluated using survey and research results as a basis, combined with existing traffic composition and volume data to predict the carrying capacity and service life.
- (2) Subgrade strength level is evaluated based on the terrain, geological conditions, and the surrounding environment of the project area.
- (3) Pavement structure type and thickness are evaluated according to the type of pavement material and its usage ^[1].
- (4) The width of the road shoulder is determined based on the construction plan, land use planning, geology along the route, highway grade, and so on.
- (5) Subgrade slope height is determined according to the height of the road subgrade and the size of the gutter.

3.2. Problems and bottlenecks on existing road

Analysis of existing problems and bottlenecks of roads is also important for construction and expansion. In this project, through inspection and assessment of the current conditions of the road, the designer summarized the following problems and bottlenecks:

- (1) The road surface is in poor condition and it is filled with ruts, subsidence, potholes, cracks, and other issues.
- (2) The roadbed and pavement structure have been damaged, and the overall stability is insufficient.
- (3) The roadside landscape and greenery have not achieved the expected results.
- (4) Facilities and management services along the road are relatively undeveloped and lacking.
- (5) The line network along the route is not complete enough to meet the needs of comprehensive transportation within the region and external transportation.
- (6) The road network of villages and towns along the line is scattered, and there is an obvious lack of rapid connection channels between towns and cities.
- (7) The horizontal and vertical surface indicators of the road cannot meet the actual design requirements, and the topography has not been rationally utilized.

3.3. Analysis of road traffic flow

The following methods are adopted in analyzing the traffic flow of the road:

- (1) Detailed investigation of the traffic flow of the road to predict the traffic volume.
- (2) Conducting a comprehensive investigation of the road traffic volume composition, traffic volume change patterns, vehicle types, and so on to analyze the main problems.

After investigation, prediction, and analysis, the designer concluded the following situations:

- (1) This road section has a large traffic volume during working days, especially during peak commuting hours.
- (2) This road also has a larger traffic volume on weekends and holidays but is lower than on weekdays ^[2].

- (3) The largest proportion of traffic vehicles is private cars, followed by public vehicles.
- (4) This road section has serious traffic congestion with very slow traffic speeds, especially during rush hours.
- (5) The traffic lights on this section of the road are poorly timed, being either too long or too short.

4. Basic principles of road route design for reconstruction and expansion

In the route design of road reconstruction and expansion projects, designers need to follow the following design principles:

- (1) Fully utilize the roads and maintain their traffic functions.
- (2) Adhere to people-oriented ideology and choose more economical technologies and methods based on meeting the functional design requirements.
- (3) Strictly control the roadbed widening range and minimize the area occupied by the construction site.
- (4) Reasonably design the width of the roadbed according to actual needs to avoid unnecessary costs.
- (5) Fully utilize the materials in road engineering and take reasonable technical measures to resolve the road issues and effectively connect the new and old roads ^[3].
- (6) Protect cultural heritage and ecological environment along the route to maintain the functionality, economy, convenience, and environmental protection of the road.

5. Design methods and steps for road reconstruction and expansion

For this highway engineering reconstruction and expansion project, the designer carried out the specific route design through the following steps, overall planning and layout design, comparison and selection of route plans, horizontal and vertical design, intersection design, and traffic safety facility design. The following is an analysis of the main design strategies.

5.1. Overall planning and layout

The overall planning layout is the most basic and critical design aspect when designing the reconstruction and expansion routes in road projects. The designer first needs to reasonably locate the road function and make a scientific formulation of the reconstruction and expansion plan based on the actual scale, traffic volume, and technical standards of the project. Then, scientific predictions should be made on the traffic volume distribution and subsequent development trends based on the current traffic volume survey results and traffic demand. A reasonable plan combined with the current status of the road project and its construction proposal will be made for the overall road network layout and various facilities. Finally, a comprehensive design is made for the road reconstruction and expansion project based on the above plan.

5.2. Route plan comparison

In the design of road project reconstruction and expansion, comparing and selecting route plans is the most critical aspect that is also a difficult part of the overall design work. Designers need to emphasize the full utilization of existing roads to reduce the cost of the overall project and protect the environment along the route. Hence, designers need to conduct a comprehensive comparative analysis of the technology, environmental protection, economy, and safety of different route plans and reasonably determine the best route design plan based on the results of the analysis. A comprehensive analysis of the impact of highway reconstruction and expansion construction on the surrounding environment should be conducted based on the natural

environmental, transportation, and socio-economic conditions of the area. Thus, a route can be designed while ensuring the area is safe, efficient, economical, and environmentally friendly ^[4]. Designers should reasonably design the traffic speed based on the traffic composition of the existing road project and its traffic volume prediction so that its application functions and safety can be well guaranteed. At the same time, the road width should be designed reasonably to minimize the road land occupation while meeting the actual traffic demand.

The designer created two route design plans for this project. The first is the existing road reconstruction and expansion design plan, and the second is the technical index plan for the new road project. For the first option, the designer considered the following factors during the comparison and selection process:

- (1) Retain the traffic capacity and service level of the existing road.
- (2) Reduce project cost and land usage as much as possible while meeting the reconstruction and expansion requirements.
- (3) Retain the existing roadbed and pavement as much as possible and reduce the amount of roadbed excavation to minimize environmental disturbance and project cost.

For the second option, the designer considered the following factors during the comparison and selection process:

- (1) Retain the transportation and service functions of the existing highway to the greatest extent possible.
- (2) Utilize economical construction technology to the maximum extent for the project.
- (3) Reasonably control the width of the roadbed in the project to meet actual traffic needs while saving land area.
- (4) Utilize materials from existing road projects to avoid material waste and reduce construction costs ^[5].
- (5) Ensure the ecological environment and cultural heritage within the construction route are well protected.

By reasonably applying the above methods, the best route design plan for the reconstruction and expansion of this road project can be selected.

5.3. Flat vertical and horizontal design

The horizontal and vertical design is also a key component of route design ^[6]. The designer used the following measures to design the horizontal and vertical sections of the road in the project:

- (1) Existing flat and vertical sections of the road surface are mainly used in the design.
- (2) In the longitudinal section design, the drainage system on the existing road surface is restored, the embankment is raised by excavating and backfilling the old roadside slope, and the retaining wall is placed on the outer edge of the roadbed, thus forming an inner and outer slope ditch. The drainage pipe is set in the internal slope trench, with the trench depth controlled at 1.0 m and below, the width at 0.6 m and above, and the slope at 1:15 and below.
- (3) In the cross-sectional design, the widening design of old roads is carried out in two ways. The first is to widen the edge of the existing road surface with a basic widening method to widen the gutter and the separation belt. The second is to use the existing separation belt and ditch in the middle of the road for a widening design with a basic widening method to widen the guardrail.

5.4. Intersection design

The designer adopted the following design strategies when designing the intersection of the road project:

- (1) The specific location, shape, and traffic organization design of the intersection should be considered ^[7]. Level intersections should be set up within a small area as much as possible, and their locations should

be consistent with driving sight distance requirements. Deceleration lanes and lane markings should be reasonably set up at the intersections.

- (2) For the signal control design at the intersection location, the current traffic signal control specifications are combined with data such as the traffic volume and vehicle driving speed of the road section to make a reasonable division of the signal control at the level intersection location for setting appropriate signal lights.
- (3) Appropriate intersection channels should be designed for the level intersection based on the road situation. For the straight intersection lane, a straight channelized lane and a straight signal control system are specially set up. For the left-turn or right-turn intersection lane, a channelized lane and a signal control system with corresponding turning directions are set up^[8].

5.5. Traffic safety facility design

The design of traffic safety facilities is crucial in highway reconstruction and expansion projects^[9]. Hence, the designer has adopted the following measures to design traffic safety facilities to ensure traffic safety in the project:

- (1) Road surface traffic signs are set up properly to optimize the driving route and prevent insufficient driving sight distance.
- (2) Road traffic markings are set up based on the road structure and traffic conditions after reconstruction and expansion to ensure accuracy^[10].
- (3) Traffic barriers should be reasonably set up to ensure traffic safety while not obstructing the vision of drivers. Guardrails should be installed at locations with poor sight distance conditions, such as flat curves by carefully considering vehicle driving speed and direction for driver safety protection.

6. Conclusion

In summary, with the continuous development of the modern highway transportation industry, more and more highway projects require reconstruction and expansion. For this type of project, reasonable route design is important to ensure the efficiency, quality, safety, and economic cost of the reconstruction and expansion construction. Hence, designers should take reasonable measures to design routes based on the operation conditions of the road projects and their specific reconstruction and expansion needs. The measures include overall planning layout design, route plan comparison and selection, horizontal and vertical design, intersection design, traffic safety facility design, and so on. In this way, a reasonable plan for the overall reconstruction and expansion of the highway project route can be made to ensure the convenience, efficiency, safety, and environmental protection of the project.

Disclosure statement

The author declares no conflict of interest.

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