China - Fujian Provincial Highway Project
EA Category A

Environmental Impact Statement
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ENVIRONMENTAL IMPACT STATEMENT

QUANZHOU-XIAMEN SECTION OF FUZHOU-XIAMEN EXPRESSWAY.
Environmental Impact Statement
Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway

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1. Administrative Summary
1.1 Origin of the Project

In order to meet the demand raised for the open-door policy and the development of the highway transport facilities along Fuzhou-Xiamen highway to solve the problem of sharp increasing of traffic on the existing coastal arteries, it's suggested that an expressway be first constructed between Quanzhou and Xiamen. After that, Xiamen-Zhangzhou Section, Fuzhou-Putian Section, Putian-Quanzhou Section will be built step by step. The design of the expressway was conducted by Fujian Provincial Communications Planning and Design Institutes (FPCPDI).

Being a component of National Route 324 from Fuzhou to Kunming, Yunnan Province, Fuzhou-Xiamen Expressway serves as a traffic artery to connect Fuzhou Economic Development Zone and Xiamen Special Economic Zone and the Xiamen-Zhangzhou-Quanzhou Economic Development Zone in the southern part of Fujian Province, acting not only as a collecting and distributing route for maritime cargos at ports, but also as a window to the world.

Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway comprises an area with fairly developed economy and its influence area covers 5696.5 KMS² with a population of 5.242 million and an average population density of 920 person/KMS² and Gross Industrial Output value of RMB 12.595 billion yuan. Since the reform, Fujian has witnessed a rapidly developed economy and a fast growth of traffic volume. According to the observations made by the traffic volume observation stations between 1980 and 1990, the daily mixed traffic (converted into medium trucks) increased at an average rate of 14.12%, resulting in frequent road accidents and low travelling speed. It's predicted that by 2000 the Gross Output Value of Agriculture and Industry along Quanzhou-Xiamen Section will reach RMB 42.70 billion yuan (on the basis of fixed price of 1980). The daily average traffic volume is 29,983 when converted into small cars and 14,992 when converted into medium trucks on the existing
Quanzhou-Xiamen Highway. In order to improve the transport infrastructure and investment environment and to develop export-oriented economy, it's extremely urgent to construct Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway.

In line with "Environmental Protection Law of PRC", "Management Guideline on Environmental Protection of Construction Projects", No. 003 issued by the State Environmental Protection Commission, State Planning Commission (SPC) and the State Economic Commission (SEC) and "Measures for Environmental Protection Management of Transport Construction Projects", No. 17 issued by MOC of PRC, Fujian Provincial Office of Freeway Construction (FOFC) entrusted in September, 1991, Fujian Provincial Environmental Protection Research Institute (FPEPRI) to prepare an Environmental Impact Statement for Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway.

1.2 Staff Assigned to EA Work

FPEPRI, awarded Licence A after the examination held by the State Environmental Protection Bureau (SEPB) and qualified for EA work for the project as a juridical personality, is responsible for the environmental assessment work. FPEPRI has once undertaken EA work for over 30 large and medium construction projects and the personnel in charge of the assessment comprised Mr. Zhou Shi Liang, senior engineer, director of the Assessment Department of FPEPRI and Mr. Chen Zhen Jin, senior engineer, director of FPEPRI. The assessment group was composed of 3 senior engineers and 10 engineers and 86 Man/month was spend on it.

Among the partners was Highway Science Research Institute (HSRI) of MOC of PRC, which was also awarded Licence A by the State Environmental Protection Bureau. Mr. Song Guo Zhen, senior engineer and director of the Assessment Department of HSRI was held the responsibility for the
engineering job analysis.

Since the environmental monitoring was conducted by such local statutory units for environmental monitoring as Quanzhou Environmental Protection Monitoring Station, Tong'en County Environmental Protection Monitoring Station, Material Structure Research Institute of the Chinese Academy of Sciences, Quanzhou Gauge Station, Xiamen University and Fujian Agricultural College, therefore, the basis data of the assessment are reliable.

1.3 The Review of Environmental Assessment in Retrospect

FPEPRI was involved in the work even at the beginning of 1990 when the alignment of road was secured. From then on, the units concerned participated in the discussions on the route selection and the relative environmental problems, and the findings was fed back to the design department on time. During this period four substantial modifications were made, each adding new measures of environmental protection. The relevant suggestions were made by the units involved in EA work in the form of "Precise of Environmental Impact Statement (EIS) of Quanzhou-Xiamen Expressway Section of Fuzhou-Xiamen Highway".

When the plan of the expressway was submitted and approved in November, 1991, the units in charge of the assessment lost no time in preparation of "Outline of EA" and submitted it to the SEPB for review, which passed the examination sponsored by the SEPB in February, 1992. On the basis of the comments made by the SEPB and the suggestions made by environmental specialists from the World Bank, EA work was conducted. In July, 1992, the field survey and 1.4 The Laws, Regulations and Criteria Applied in EA Work

1.4.1 The Basis on which the Assessment was made.

(c) Environmental Protection Law of PRC.
1.4.2 The Scope of the Assessment.
EA work for Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway comprises:

1) the Expressway Section (81.40 KM in length) between Xifu in Quanzhou and Quanlintou in Xiamen;
2) Class 1 automobile accommodation Highway (7.57 KM in length) from Tiancuo to Jimai, Xiamen;
3) Class II Highway (6.26 KM in length) from Wuling to Shedian, Jinjiang.

The Assessment work is composed of the survey and assessment on the status quo of Environment in the key areas along the sections mentioned above, the prediction of environmental impacts during construction and operation and making environmental protection countermeasures and suggestions.

The scope of the assessment on the atmospheric environmental impact covers an area 500 meters from each side of the central line of the proposed expressway. The noise and vibration studies include a belt area up to 500 meters from each shoulder of the expressway.

1.4.3 Environmental Standards

1) Atmospheric Background Quality Standard (GB 3095-85)
2) Ambient Noise Standard For Urban Areas (GB3096-82)
3) Maximum Permissible Concentration of Atmospheric Pollutants for the Protection of Agricultural Crops (GB9137-88)
4) Farmland Irrigation Water Quality Standards (GB5084-85)
5) Environmental Quality Standards of Surface Water (GB3838-83)
6) Sea Water Quality Standards (GB3097-82)
7) Environmental Vibration Standards in City Regions (GB10070-88)
8) Lead and Inorganic Compounds Hygienic Standards of Atmospheric (GB7955-87)
9) Noise Criteria for Construction Sites (GB12523-91)

The criteria for evaluation for the areas can be seen in Table 1-1.
1.5 The main Methodology Applied in EA work

The methodology applied in EA work comprises field monitoring, collection of data, analogical survey and computerized simulation.

Since every effort was made to keep the alignment of the expressway away from towns and residential areas and there is few original data, field monitorings were adopted, including atmospheric environmental monitoring, water environmental monitoring, acoustic environmental monitoring, vibration environmental monitoring and aquatic organism environmental monitoring. On the whole, the meteorological and hydrological data required a long-term accumulation. Such being the case, the data from the relative meteorological observatories and hydrologic stations were used in accordance with the relevant regulations in China. Some supplementary observations were made, for instance, the local turbulence and ground wind field were observed by using triaxial wind meters.

The ecological environmental assessment was carried out in the form of field investigations and the survey was made in every village and town to obtain the first-hand information, on the basis of which the assessment and predictions were conducted.

In order to let more local people participate in the assessment work, the sampling surveys of the residents living along the route were carried out, forums held and visits paid to some families and individuals.

In the environmental prediction, the first place was given to the computerized simulations at the same time, in combination with analogical surveys. The mathematical models applied were the mature ones both in China and abroad, which were so examined and approved by the specialists.
in the process of the assessment of the outline as to enhance the reliability of the prediction.

1.6 Public Participation in EA

EA work in China is for the purpose of protecting the living environment of the people. In conformity with this, the EA work should be carried out with the involvement of the local people.

Generally speaking, hearings are adopted in the developed countries. Anyone who is willing to participate may go to the meetings to obtain the relative information, and to air their views and make requirements. However, the weakness of this type of investigation lies in the fact that on the day people should leave their posts and give up their rests to attend the meeting, therefore, the number of people who can go to the meetings may be limited. In addition, fewer people will have a chance to air their opinions due to the limitation of time. As far as the units in charge of the assessment are concerned, what they can do is to add the opinions and comments from the hearings to their completed EA reports. Taking all this into accounts, the hearings may be no more than a passive assessment method.

The actual conditions in China, the wide distribution of the families living along the route and the different understanding about the environmental problems may make hearings unpractical, and the local people may not spend so much time and money to participate in the hearings. For this reason, what was adopted in EA work was that EA assessors made a direct observation on the residents along the route, which was an active assessment. The EA assessors held face-to-face talks with the local people to inform them of the environmental problems and hear the opinions and requirements of the local residents. Such a way of doing things was characteristic of:
(A) Involving more people and exerting no influence on their work and rest and adding no additional outlay of local people.

(B) Being able to collect widely different opinions, for example, some people were in favour of the project while others were against it. Some raised problems while others put forward suggestions.

(C) Guaranteeing all people, men and women, old and young, the freedom to air their ideas regardless of their educational backgrounds. At the same time, no body felt constrained when airing their views.

(D) Scientifically speaking, such a stochastic method had adequate representation and the data obtained in the process was in conformity with statistical theory.

Therefore, what was adopted by the Environmental Assessors in the direct observations on the local people along the route is in line with the national conditions of our country, adapting itself to the current states of the social, political and economic activities and living and educational levels and is on the basis of science and rationality.

In the process of the sample surveys of the residents along the alignment, 130 households were investigated, among which 51 would be displaced. The outcomes of the survey would be addressed in Section 4.8. The results of the surveys revealed that if the problems of the resettlement were properly solved, the living standards of the people along the route wouldn't be lowered and they would give support to the construction of the expressway.

1.7 The Main Conclusions of EA work

The details and conclusions of EA work will be addressed in the following chapters.

Here the comprehensive assessment on the Environment Impacts stemming from the proposed highway will be carried out by tabulating.
method, which is also a good way for environmental screening. The results may be seen in Table 1-2.

The Tabulating method is on the basis of grading technology, and the impacts are graded by their severity, advantages and disadvantages. The negative figures represent adverse impacts. Positive figures stand for favourable influences while zeros represent no impacts or little impacts. In the overall evaluation, if the total sum of the positives is greater than that of the negatives, the results indicate that the favourable impacts exceeds the adverse ones. From Table 1-2, it may be concluded that the sum of the favourable impact values in operation phase stands at +22, and that of the adverse impact values at -9, the favourable impacts during construction stand at +1, while the adverse impacts at -9, indicating that the adverse impacts only exist in the construction phase. After the completion of the expressway, favourable factors will surpass the unfavourable ones. Therefore, it's very necessary to construct the expressway.

The environmental protection measures will be elaborated in Section 6.2. Conclusions are as follows:

(1) Through the environmental assessment, the principles followed in the process of location of line to keep the alignment away from the residential areas and minimize the demolition are considered as appropriate and the layout of the alignment is rational.

(2) It's recommended that the alignment near Xiahouba village at the foot of Mt. Xiaoyingling be further compared, keeping it from the village.

(3) No residential quarters, institutions and schools should be established within 100 meters from each sides of the expressway in future.

(4) EA work reveals that the project is environmentally acceptable on
condition that various protection measures identified in the following chapters be applied.

II. Project Description

2.1 The Route Strike of the Expressway and the Main Works.

Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway is 81.40 KM in length. The starting point will be located near K185+720 on the existing Fuzhou-Xiamen Highway in the vicinity of Xifu of Quanzhou. The terminal will be at Guanlintou in Guanxou District of Xiamen, intersecting National Highway NO. 319. Extending southward from Xifu, it passes by Quanzhou-Xiamen Highway, it passes by Xifu at K0+600 and through Yulan Village and Dongxing Village, continuing its route through Mt. Dapingshan Road Tunnel (1100 M) at K5+200 to K3+588 to intersect Quanzhou-Xiutu Highway, where an interchange is to be constructed. After passing by Chenzhou and crossing over Jinjiang River at K9+950, it takes its route via Liushi to intersect Quanzhou-Qingshi Highway near K13+700. After passing by Zengyun, Chidian, Shantou, Laicuo, Zhanglin, Shangwulong to Wulin at K21+500 where an interchange will be erected. The alignment takes its route southward further by way of Banwei, Dazhai, Ciyuan, Ganshi, Shangling of Neiken at K28+180, Louzi at K32+780 in Nan'an County, the intermediate zone between Xiwei and Shanglin to go through Xiwei Bridge (206 meters) at K33+500. Passing through Zhangzhai and at K34+180 intersecting the existing Fuzhou-Xiamen Highway by Puli Interchange which is located at 226+840 on the existing Fuzhou-Xiamen Highway, it travels via Kanglong Primary School and Sucuo to pass through Sucuo Road Tunnel (350 meters) at K39+630, Shantou Road Tunnel (580 meters) at K40+500 and Shantou Village. Along the slope on the right side of the existing Fuzhou-Xiamen Highway, it runs by way of Jincuo, Xiaokouba to go through Mt. Xiaoyingling Road Tunnel (560 meters). After passing
through Xiashexi Road Tunnel (250 meters) at K46+300, the route curves out its way via Xiashexi, Tianzhouyang, Liantang, Mixianhu and the junction between Zenglin and Hou'an to intersect K253+030 on the existing Fuzhou-Xiamen Highway at K55+780 in Luntou by an interchange. Before passing through Shixun Large Bridge (606 meters) at K60+860 in Shixun and crossing over Xixi River in Tong'an County at K61+850, it goes via Xiongshen, Neiguan, Longjuedong, Longjuesi. After passing Putou, it intersects the existing Fuzhou-Xiamen Highway by an interchange at K65+500 in Hou'an. After running through Songcuo Large Bridge (126 meters) it goes by way of Chuantulou of Shanwei to pass through Mt. Damaoshan Road Tunnel (860 meters) at K71 and Tiancuo by an interchange, ending up at Guanlintou, the terminal, by way of Dongzhai, Tian Tou and Ilumei. The route alignment can be seen in Map 2.

There are two link roads for the expressway section:

(A) Class I automobile accommodation road between Tiancuo and Jimei, totals 7.57 KM with Tiancuo Interchange as its origin and Jimei as its terminal via Duishan and Songcuo.

(B) Class II highway between Wulin and Shedian totals 6.26 KM with Wulin Interchange as its origin and Shedian as its terminal via Zhanglin and Gongqian.

The main works for Quanzhou-Xiamen section of Fuzhou-Xiamen Expressway comprises six interchanges, five large bridges, six twin-barrel tunnels. The details of scale of construction and technical criteria can be seen in Table 2-1.

The findings of projection of the future traffic volume of Quanzhou-Xiamen Expressway Section may be seen in Table 2-2.

2.2 Comparison and Selection of the Engineering Alternatives.

From the beginning of 1989, three years were spent by FPDPDI in
making field reconnaissances, investigations, surveys and designing. During this period, "Prefeasibility Study Report for Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway", "Prefeasibility Study Supplementary Report", "Engineering Feasibility Study Report for Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway" and "Engineering Feasibility Study Supplementary Report" were prepared one by one, and for four times, the specialists from the province and other provinces were organized to make project appraisals and the departments concerned and local governments were called in for consultations. In the location survey, FFCPDI devoted every effort to keep the alignment away from such sensitive spots as the residential areas and schools for the purpose of reducing disturbance and protecting natural landscape.

The starting section of the alternative line would pass Overseas Chinese University, which might exert a great influence on the environment.

Closely paralleling Fuzhou-Xiamen Highway, the alignment would pass by several villages from Hou'an to Duishan and the noise impact problem could not be solved. At last, it was decided that the alignment would cut through Tianma Stud. Taking all into accounts, the two options were not environmentally acceptable.

In March, 1993, China International Engineering Consulting Corporation carried out assessments and screening on the alternatives.

At last, the route strike was decided with Xifu in Quanzhou as its origin and Guanlintou in Xiamen as its terminal.

2. Traffic Forecast for Expressway and Economic benefits Stemming From the Expressway.

In accordance with the relevant relationship between economic development of Fujian Province and the highway freight/passerger volume
in the province, four prognostic equations can be obtained:

1. The Relationship between Highway Freight Volume and Industrial and Agricultural Output Value.

\[ Y = 5420.791 + 13.5833X \quad (R=0.77) \]

where: \( Y \) — Highway Freight Volume, in 10,000 tonnes;
\( X \) — Industrial and Agricultural Output Value (IAOV), in RMB 100 million yuan.

2. The Relationship Between Highway Freight Turnover and IAOV.

\[ Y = 1433.399X^{0.7171}\quad (R=0.96) \]

where: \( Y \) — Freight turnover (10,000 tonnes/100);
\( X \) — IAOV (RMB 100 million yuan)

3. The Relationship Between Passenger Volume and Per Capita National Income

\[ Y = 74.29X^{0.96} \quad (R=0.96) \]

where: \( Y \) — Passenger Volume on Roads, in 10,000 persons;
\( X \) — Per Capita National Income (PCNI), in RMB yuan

4. The Relationship between Highway Passenger Turnover and PCNI.

\[ Y = 1555.79X^{0.96} \quad (R=0.98) \]

where: \( Y \) — Passenger turnover on Roads (10,000 persons/100);
\( X \) — PCNI (RMB yuan)

On the basis of the above prognostic equations, the predictions have been made and the outcomes can be seen in Table 2-3.

Traffic structures in the area will be changed due to the construction of Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway, resulting in the acceleration of passenger/goods turnover, the reduction
of intercity travel time and more rational distribution of economic nodes between zones to induce higher rate of economic growth. Based on the experience both at home and abroad about induced economic development, the induced economy in the direct influence zone is predicted to be 2% of the economy of tendency in 1997, and increases to 5% in 2000, 10% in 2005, and at a stable rate of tendency thereafter. The completion of the expressway segment will thereby give a direct impetus to the economic development in the region.

In addition, the foreign experience shows that a commercial or service center may appear around an interchange. Thus, a new commercial network and towns may be established near or around the six interchanges in future.

The completion of the expressway will provide a stimulus to the tourism in Quanzhou and Xiamen. And Zhengchenggong (a national hero) Tomb in Nan'an County will probably become a new hot resort, creating new scenic spots from Anping Bridge to Zhengchenggong Tomb.

The benefits obtained by the all-social road users may comprise: the reduction of passenger/goods operation costs due to the construction of the highway; the reduced transport costs because of the shortened mileage; the benefits from the induced traffic: saving of travel time and decrease of road accidents, damaged cargoes and traffic congestion. The benefits of national economy have been listed in Table 2-4, from which we can see that the remarkable benefits generated from the expressway will reach RMB 11.42 billion yuan during a period of 20 years.

2.4 The Impacts of Engineering Geology and Geohydrology

The Elevation and Mileage along Quanzhou-Xiamen Expressway Section. There is a 29.9 KM-long section at the elevation of 0-10 meters, accounting for 36.9% of the total length. The 18.1 KM-long alignment is
seated at the elevation of 10-20 meters, accounting for 22.3%. The 19.9 KM long route is at the elevation of 20-40 meters, accounting for 24.5%. The mileage at the elevation of over 40 meters is 13.2 KM, accounting for 16.3%. The lowest elevation is zero meter at K33+500 where Xiwei Large Bridge over Shijing River is located. The maximum elevation is 140-200 meters above the sea level at K71+200 where Mt. Damaoshan Road Tunnel is to be cut. The key sections which may be impacted by engineering geology and geohydrology are the segments at the elevation of 0-10 meters.

(1) the sections at the elevation of 0-10 meters.

The total length of the road sections at the elevation of 0-10 meters is 29.9 KM, along which 3 extra large bridges and large bridges with a total length of 2281.8 meters and 21 medium- and small-sized bridges will be built. The surface runoff of rivers in the drainage basin converges into Luoyang River, Jinjiang River, Shijing River and Xixi River respectively. Because these rivers are close to the East Sea, the runoff of peak flood caused by the rain storms can empty into the sea very quickly. Because they are affected by sea tides to some extent, man-made embankments are built on both sides of the rivers. There are six embankments at the elevation of 0-10 meters.

a. In the section (about 4.6 KM) from K0+000 to K4+600, the rivers and surface runoff converge into Luoyang River. There are two large bridges, Yulan Large Bridge and Dongxing Large Bridge, 2 medium- and small-sized bridges and 30 culverts, average 6.5 culverts per kilometer. The river bed has been constricted and the water discharges itself freely without anything to block the water flow to produce an impact on the ecological environment.

b. The section from K7+300 to K11-200 is 3.9 KM long, the rivers and surface runoff come into Jinjiang River. Extra Large Jinjiang Bridge is 1
980 meters long, accounting for 51.0% of the total length of the section. There are no medium- and small-sized bridges and culverts. The narrowest part of Jinjiang River Channel is about 300 meters. The river wall level is 6.2 meters with an average ground elevation of 2.7 meters. It is 3.5 meters from the ground to the top of the embankments. The length of the designed bridge is 6 times the width of the river channel. This river section will produce no impact on flood discharge.

c. In the section (6.4 KM in length) from K13+300 to K19+700, 5 medium- and small-sized bridges with a total length of 311 meters and 16 culverts, averaging 2.5 culverts per kilometer, will be built to meet the basic requirements for agricultural irrigation and flood discharge.

d. Xiwei Large Bridge and five medium- and small-sized bridges with a total length of 175 meters and four culverts will be built in the 2.1 KM long section from K32+300 to K34+400. In this section, rivers and surface runoff converge into Shijing River. All these structures to be built can basically conform to the native state of the rivers.

e. Five bridges, including extra large Shixun Bridge, Putou Large Bridge and other medium- and small-sized bridges with a total length of 1662 meters will be built in the 8.4 KM-long section from K56+300 to K64+700 where rivers and surface runoff flow into Xixi River. In addition, 29 culverts will be constructed, averaging 3.53 culverts per kilometer, to satisfy the requirements for farmland irrigation and flood discharge.

f. There are three medium- and small-sized bridges in the section (4.3 KM in length) from K73+200 to K73+000, totaling 128 meters and 12 culverts, averaging 3.1 culverts/bridges per kilometer, will be built to meet the basic requirements for flood discharge and farmland irrigation. In the design and construction, attention should be paid to the actual need.
Section at the Elevation of 10-20 Meters.

Action is a segment in the balance of cuts and fills, or a cut-transition section. There are ten segments of this kind along the line with a total length of 38 Km. In this section, two large totalling 956 meters, three medium- and small-sized bridges, 132. 6 meters and 16 culverts will be constructed to meet the end for flood discharge and farmland irrigation. However, in the very effort should be made not to destroy the native state of system and measures must be made to restore the damaged native cap. In the construction, entries and exits of culverts must be ensure that the water may flaw freely.

Sections at the Elevation of over 40 Meters.

The attention should be paid in this section is to prevent on. There is a little rain in winter and fall, however, the abundant with annual rainfall of 1. 111-1. 667 mm. which ised in spring and summer. The period from July to September is season when the typhoon storms account for 35% of the annual ion with strong scouring force. In addition to the subsurface in Granite Eluvium, attention should be paid to guard the xy against slumps when working on cuts and tunnel cutting. In the mortar-bonded rubble slope should be adopted to protect slope. The wastes from the tunnel cutting should be disposed of place, occupying no or little farmland. Protective measures ade to prevent soil loss and programs be outlined for land afforestation and rehabilitation of vegetation in protection ogical environment. Be made to prevent soil loss and programs utlined for land reclamation, afforestation and rehabilitation on in protection of the ecological environment.
(2) The Section at the Elevation of 10-20 Meters.

The section is a segment in the balance of cuts and fills, or a cut-and-fill transition section. There are ten segments of this kind along this section with a total length of 38 km. In this section, two large bridges, totalling 956 meters, three medium- and small-sized bridges, totalling 132.6 meters and 16 culverts will be constructed to meet the basic demand for flood discharge and farmland irrigation. However, in the design, every effort should be made not to destroy the native state of the water system, and measures must be made to restore the damaged native water system. In the construction, entries and exits of culverts must be repaired to ensure that the water may flow freely.

(3) Sections at the Elevation of over 40 Meters.

To what the attention should be paid in this section is to prevent soil erosion. There is a little rain in winter and fall, however, the rainfall is abundant with annual rainfall of 1,111-1,667 mm, which is concentrated in spring and summer. The period from July to September is the typhoon season when the typhoon storms account for 35% of the annual precipitation with strong scouring force. In addition to the subsurface void water in Granite Eluvium, attention should be paid to guard the mountain body against slump when working on cuts and tunnel cutting. In the design, the mortar-bonded rubble slope should be adopted to protect the earth slope. The wastes from the tunnel cutting should be disposed of in a proper place, occupying no or little farmland. Protective measures should be made to prevent soil loss and programs be outlined for land reclamation, afforestation and rehabilitation of vegetation in protection of the ecological environment. Be made to prevent soil loss and programs should be outlined for land reclamation, afforestation and rehabilitation of vegetation in protection of the ecological environment.
2.5 Construction Planning and Environmental Management

The gross investment of the project is RMB 1.670 billion yuan, among which RMB 1.59 billion yuan will be spent on the construction of the expressway and RMB 80 million yuan will be spent on the link roads. Details are given in Table 2-5.

To ensure the quality and the timely completion of the project, it's assumed that contractors with Grade A qualifications should be involved in the construction and the subsections should be under construction at a labour-equipment ratio of 1:9.

Based on "Engineering Feasibility Study for Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway" compiled by FPCPD in November, 1991 and "Engineering Feasibility Study Supplementary Report" in May, 1992, the commencement of the project is scheduled in July, 1994 and the completion of the project will be expected at the end of 1997. The main works, manpower and materials required are given in Table 2-6 and Table 2-7.

Since the soft ground treatment, interchanges, pavement engineering, tunnels and extra large bridges are the key components in the project, a 2.7km-long section of soft ground will be arranged to be treated and tested in advance within 1992 to ensure the construction quality.

Environmental Management in Construction:

The construction must be carried out in accordance with the environmental action plan in construction and the environmental protection provisions must be stipulated in the bidding contract of construction, including the time bar of the construction activities. The environmental protection facilities at the construction camps, water and soil conservation in cut and fill, and afforestation, etc. In chapter 5, details will be addressed.

The involvement of environmental management in the project reads as:
follows:

(1) In the phase of feasibility study: EIA

(2) In the phase of design: Environmental protection Facility Design.

(3) In the phase of Construction: persons from Environmental Protection department will be sent to supervise the construction sites and on-the-spot monitoring will be carried out when necessary.

(4) In the phase of acceptance of completion: The environmental protection department will make an acceptance check of the environmental protection facilities and carry out acceptance tests.

(5) In the phase of operation: Periodical environmental monitorings will be exercised.

2.6 Traffic Management Plan in Construction

The main impacts the construction of the expressway may exert on the traffic can be divided into two parts:

(1) the traffic congestion in the construction; (2) an increase of vehicle streams and traffic loading due to the material transportation for highway building. Therefore, a Traffic Management Plan has been put forward and reads as follows:

A. Before the commencement of the project, temporary access roads must be constructed in the sections in which flying junctions and interchanges will be built to intersect the existing Fuzhou-Xiamen Highway and traffic arteries. The construction period must be reduced in every possible way to avoid traffic congestions. In the section where access roads are not available and it's necessary for traffic interruption, construction should will be built to intersect the existing Fuzhou-Xiamen Highway and traffic arteries. The construction period must be reduced in every possible way to avoid traffic congestions. In the section where access roads are not available and it's necessary for
traffic interruption, construction should be carried out during a period from 20:00 to 5:00 next day and the circulars be issued.

B. 70 million cubic meters of earth and stone required for the fill construction of the highway will be secured nearby. From the list of borrow areas and filling areas (see Table 4-3-3 and Table 4-3-4) we can see the haul distance is 1-2 KM on average. Since the haul roads don't intersect the existing highway, the temporary access roads can be built for transportation and produce no impacts on the transportation on the existing arteries.

C. Other Raw Materials: Sand, crushed gravels and block stones are available in the material yards nearby.

D. 510,000 tonnes of building materials such as steels, timber, cement and bitumen will be transported from other places requiring 120,000 trucks for their transportation. Calculated on the basis of 3 years, the traffic stream will increase by 120 vehicles per day, on the average. As far as the current traffic conditions are concerned, there will be no big problems, but the rush job of transportation of bulk commodities should be done in the evenings.

2.7 Plan for the Protection of Historical Relics.

Cultural relics are the precious historical heritages. They tend to diminish gradually instead of renewal. For this reason, they should be treasured and cherished. The current outcomes of the surveys show that no historical sites and ancient tomb groups have been found along the route except Tongming'an pass on Mt. Xiaoyingling, which is an antiquities preservation unit at county level.

In the construction of the expressway, attention should be paid to the protection of cultural relics. On the basis of this, measures have been made as follows:
A. Particular attention should be paid in protection of Tóngmíng'án Pass in the design and the construction of Mt. Xiaoyingling Tunnel. High-tensile Blasting should be forbidden for fear of damaging the historic site.

B. A person in charge of the protection of antiquities in the construction will be sent by each construction unit to study in the Cultural Relics Research Institute.

C. Prior to the construction, all persons involved in the construction should secure the education about the protection of the antiquities along the route.

D. In the construction of the expressway, the construction activities should be stopped immediately whenever coming across the ancient tombs and potential historic sites. Report to the antiquities Preservation units and ask them to deal with them.

2.8 Displacement of the Local People

Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway is 31.4 KM in length with a subgrade width of 26 meters. The link road between Tiancun and Jimei is 7.57 Km in length with a subgrade width of 21.5 meters. The link road from Wuling to Shedian is 6.26 KM long with a subgrade width of 12.0 meters. In the areas 100 meters from each side of the center line of the highway, there are 52 towns and villages with 1,748 households. 7,000 persons are expected to be impacted to some extent. 97.2 square meters of structures will be demolished due to the land acquisition for the right-of-way, among which 61,617 m² of houses are built with wood, brick and stone, and 15,677 m² are simply-constructed dwelling houses. The houses to be demolished in the cities, counties and districts can be seen in Table 2-8.

Land acquired for the project is given in Table 2-9.
Compensation for land acquisition for the expressway and the link roads is given in Table 2-10.

The resettlement plan should be prepared immediately after the project is officially approved. This plan will be carried out by 8 stages.

(1) The design department will determine the scope of resettlement and the number of households.

(2) Fujian Provincial Office of Freeway Construction will prepare a Resettlement Action Plan.

(3) The provincial government will work out a uniform subsidy standard and preferential policy.

(4) The provincial government will call a meeting with the involvement of municipality/county governments for resettlement.

(5) The municipality/county governments will take full responsibility for the resettlement under their jurisdiction.

(6) Displacement of the local people.

(7) Revisit the displaced people after the resettlement to solve the problems left over from the resettlement.

(8) Prepare a summary report on the resettlement for the provincial government.

At present, the provincial government is making an overall plan and arrangement for the resettlement. The municipality/county governments will be held full responsibility for putting the plan into practice. The detailed program is in preparation.

III. The Status quo of the Environment
3.1 The Scope of Studies

The scope of studies is designated in an area 100-500 meters from each side of the highway in the light of different environmental factors, and is divided into 7 sections. i.e. Section from Xifu to Chenzhou, Section from Chenzhou to Wuling, Section from Wuling to Pull, Section from Pull to Luntou, Section from Luntou to Hou'an, Section from Hou'an to Tiancuo and Section from Tiancuo to Guanlintou.

The scope of studies on the waters is 500 meters at the lower reaches of four major rivers—Jinjiang River, Nanqu River, Xixi River and Jixi River over which the expressway will cross.

3.2 Natural Environment

3.2.1 Meteorology

It's obvious that there is a subtropical maritime monsoon climate with moderate temperature and humidity along Quanzhou-Xiamen section of Fuzhou-Xiamen Expressway. Summers are long and winters are short. All year long, predominant wind is East wind. But in summer south wind prevails and in winter east wind is predominant characterized by low frequency of stagnant air and great velocity of wind. The period from July to September is the typhoon season, a disastrous weather. The main meteorological features can be seen in Table 3-2-1.

Temperature: The temperatures differ little in the zones along the route. The annual average temperature is 20.4-21.0°C. The annual average highest temperature is 24.4-25.6°C and the annual average lowest temperature is 17.3-17.6°C. The absolute temperatures, highest and lowest, are 38.3-39.0°C and -1.8-0.9°C respectively.
The Ground Wind: The annual average wind velocity in the northern part of the route is greater than that in the southern part of the route. Monthly mean wind velocity are given in Table 3-2-2.

Wind Direction: NE wind prevails in the northern part of the road while E wind predominates in the southern part. The frequency of stagnant air in the southern part with 21.5% in Nan'san County and 23.3% in Tons'an County is greater than that in the northern part of the route with 13.8% in Quanzhou and 10.3% in Jinjiang County. In summer, South wind prevails along the route. The wind rose of Quanzhou, Jinjiang County and Tons'an County can be seen in Fig 3.

Atmospheric Stability: D stability of atmosphere dominates according for 70.7% of the various stabilities, while C and B stabilities account for 11.6% and 10.7% respectively.

Atmospheric Turbulence Diffusion Properties: The highway alignment passes through slightly undulating hills and terraces. The results of on-the-spot checks in the flat and open areas indicate that the atmospheric turbulence scale along the right-of-way is greater than that in the plain areas. The diffusivity is one scale higher than cross-wind direction in the plain areas, and half or one scale higher in the vertical direction.

There is a abundant rainfall along the route, ranging between 1090.3 mm and 1473.2 mm. The number of rainy days (> 25mm) is between 12.0 and 17.7, mainly concentrated in a period from May to September. The construction in this period will easily give rise to soil erosion. Details can be seen in Table 3-2-3 and Table 3-2-4.
3.3.2 Terrains and Topographic Features.

The alignment of the section passes through the southeast region of Fujian Province, in which the red soil terraces and low hillocks account for two thirds and river network, alluvial deposit, diluvial deposit and maritime deposit account for one third. On the whole, the region is characterized by a terrain which is higher in the west and lower in the east with a stepped increase from east to west. The plain, belonging to Quanzhou maritime deposit plain at the elevation of no more than 25 meters, is densely interwoven with a network of rivers and a main area in which rice is planted. The red soil terraces belong to granite hillock, covered with a thick red soil solum, 40-50 meters above the sea level. This area is the main region producing sweet potatoes, peanuts and beans. The hilly country is characteristic of denuded granite remnant hills at the elevation of 50-250 meters with a gradient of 15-18°. Exposed on the ground are stone chips and half-weathered residuum suitable for forestry.

In brief, this section has a little longitudinal undulation with an average ground slope below 20°.

Of the terrains in the zones through which the alignment will pass, the plains account for 16% of the total length of the route, terraces and hills account for 84% and the difference of relative altitudes is only 10 meters, advantageous to the construction of expressway.

3.3.3 Soil Category and Distribution

According to the features of terrains, climates, hydrology and geology, and in reference to the soil investigation made in the province.
the soil along the expressway may, in the main, be divided into: laterite red soil, red soil, paddy soil and coarse-textured red soil.

(1) Laterite Red Soil: The soil horizon is thick (8-15 meters) with fully developed solon. The soil profile structure is A-B-C in a lateritious color from top to bottom. The organic matters in the topsoil is 1.14-2.13 with a PH value of the soil of 5.0-5.8. This type of soil is mainly distributed in the section between Pul and Luntou. Part of it is located from Hou’an to Hunei. Other sections have a limited distribution.

(2) Coarse-Textured Red Soil: The soil horizon is rather thin and less saturated with a vague stratified differentiation and the soil structure is A-C. The organic matters in the topsoil is 0.5-1.4% with a PH value of the soil ranging between 5.5 and 5.6. Such a type of soil is mainly dispersed in the steep terrains along the expressway, for instance, at Mt. Dapingshan and near Mt. Xiaoyingling Road Tunnel.

(3) Paddy soil: This type of soil has been developed into saturation from alluvion and coastal sediments after a long-term of irrigated agriculture. Most of the paddy soil along the route is of submerged cultivation. The plowed soil is 20-25 cm thick with clear-cut stratification. The organic matters in the topsoil is quite rich, being 2.32-2.81% with a PH value of the soil of 6.5-7.0. Such a type of soil is mainly dispersed in the open and flat terrains along the route with better water conditions. In the sections from Guokeng to Yulan and from Xingdian to Neikeng there is a large distribution of paddy soil.

(4) Red Soil: The soil developed to a high degree of maturation from
alluvial deposits and residuum after a long-term of dry farming. The soil horizon is 10-20 meters thick with fully matured solum and a clear-cut stratified differentiation of A-B-C. The organic matters in the ploughed soil is 1. 65±2. 52% with a pH value of soil of 6. 2-7. 4. This type of soil is distributed on the terraces within the sections from Liushi to Cidian and from Neikeng to Puli.

3.2.4 Vegetation

The regions through which the expressway passes are located in the subtropical rain forest zone. The maritime monsoon climate provides an excellent condition for the growth of plants. Tradition has it that there was a dense plant community in ancient times with tall trees sticking to the sky characterized by tropical rain forest. Due to the long term of deforestation, the native vegetation has been out of existence. The existing vegetation is secondary and planted vegetation.

(1) Secondary Vegetation

This kind of vegetation has a limited distribution along the road. Except for the secondary vegetation outside Shantou Village of Shuitou Town, most of the secondary forests with few tree species are low and thinly scattered. Even the tree establishment, if any, is rarefactional. The phytocoenosis is mainly composed of Pinus massoniana, Rhodemus tomentosa Hassk. burr. Taiwan acacias and woods, most of which are scattered on the hills with 43.8% of plant coverage.

(2) Planted Vegetation

The planted vegetation forms a dominant proportion in the zones through which the expressway will pass, accounting for 34.5%. It can be separated into 3 groups in view of their features.
(1) Conifer Forest and Broadleaf Forest.

The commonly seen tree species are casuarinas, Pinus massoniana, Taiwan acacias, swamp mahogany, bamboo and China fir, occupying small areas of the region and serving the function of yield sharing forest and protection belt along the villages and roads.

(2) Production Forest:

There is a large distribution along the sections at Cizao in Jinjiang County and at Shuitou in Nan'an County. Of the production forests, orchards predominate with longan trees, lychee trees, guava and persimmon trees.

(3) Agricultural Crops

Crops cultivation occupies most of the areas along the route in which rice, sugarcanes, sweetpotatoes, peanuts, beans and vegetables grow.

3.2.5 Rivers and Water System

The big rivers over which the expressway strides are Jinjiang River, Jiushixi River, Jixi River in Nan'an County, Xixi River in Tong'an County and Gunxunxi River. The others the expressway get over are brooks.

Jinjiang River, the fourth largest river in Fujian Province, is separated into two creeks at the upper reaches known as East Creek and West Creek. They meet at Shuangxikou in Nan'an County to form Jinjiang River with a 632-KM trunk stream and a total length of 302 KM. The catchment area is 5629 square kilometers.

The data provided by the gage stations indicate that the annual average flow amount of Jinjiang River is 163 m³/s, and the annual runoff amount is 5.13 billion cubic meters with a headwater channel of Shenzhen-Jinjiang Irrigation District to irrigate an area of 140,000 mu.

Jiushixi River, originating in Mt. Fengchao in Nan'an County, meets Nanxi Channel in Jinjiang County at Jinsha via Cidian, merging into Jinjiang River and emptying itself into sea by way of Shuangxi and Chendai. The total length of it is 37 KM with a catchment area of 257 square kilometers.

Jixi River originates in the boundary between Nan'an County and Tong'an County where Shibi Reservoir was built. The river empties itself into the sea via Shuitou.

The trunk stream of Xixi River, the biggest river in Tong'an County, originates from Mt. Fengguan in the west of Tong'an County with a total length of 34 KM and a drainage area of 494 square kilometers.

The length of the other brooks the expressway crosses over is no more than 20 KM with great variation of current velocity. Their water levels go up and down sharply with the rainfall volume. In the dry season, they may dry up. At the upper reaches of most brooks medium- and small-sized reservoirs were built. And at the lower reaches of some, especially at the river mouth to sea, the sluice gates were installed for the farmland irrigation.

3.3 Social Environment

The zones through which the expressway passes have favourable natural conditions with abundant agricultural resources and great social-economic development potential due to the well-developed traffic. Many towns and villages are the famous hometown of overseas Chinese. At present, the agricultural economy has been gradually transferred from
The basic conditions of the cities and counties along the route are given Table 3-3-1.

The features of the economic development in the zones are:

1. Extremely active export-oriented economy:
   Along Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway is a belt where export-oriented economy is under active development and it is also an investment hub for foreign investors. By the end of 1988, only Xiamen Economic Special Zone saw 638 projects signed under agreements with a foreign investment of $957.10 million and an output value of foreign-funded enterprises of RMB 3.677 billion yuan. In 1988, Quanzhou City signed 2681 contracts for processing and assembling with a volume of business of $61.20 million. Besides Xiamen Economic Special Zone, the regions along the route are experiencing an upsurge in large-scale land development. For instance, Chenzhou Industrial Development Zone in Quanzhou is close to Quanzhou Interchange, Penlong Development Zone in Nan'an County is only 1,500 meters from the expressway, Anping Development Zone is 3 KM from Puli Interchange, Fupu Development Zone in Jinjiang County is just beside the terminal of Jinjiang Link Road and on the side of the expressway terminal. Xiamen Asian Industrial City will be established.

2. Rapid Development of Township Enterprises.
   The total value generated by Jinjiang County's township enterprises was RMB 1.093 billion yuan in 1988, RMB 1.282 billion yuan in 1989, RMB 1.699 billion yuan in 1990 with an increase of 17.3% in 1989 compared with that in 1988 and a growth of 32.5% in 1990 over 1989. 1991 witnessed a sharp increase of numbers of township enterprises in Nan’an County, Tong’an County and Jinjiang County.

3. Great Traffic Volume
   Being a primary port of the country, Xiamen harbour had a handling capacity of 5.289 million tons in 1990 with 3.543 million tons of cargos imported and 1.746 million tons of cargos exported. With an annual handling capacity of 1,015 million tons, Quanzhou Harbour witnessed 0.67 million tons of cargos imported and 0.345 tons of cargos exported. Besides those mentioned above, there are some medium- and small-sized ports along the coast.

   The traffic grew rapidly in Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway. The period from 1980 to 1990 saw an increase of 2.02 times in highway traffic with an annual average growth of 14.19%.

Therefore, the construction of Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway will give an active impetus for the economic development in the Delta in the southern part of Fujian Province.

In order to have a better understanding of the social-economic conditions in the zones along the route, a detailed investigation has been made on the industrial and agricultural production within a scope 250 meters from each side of the highway. The results will be addressed as follows:

3.3.1 The Conditions of Population and Cultivated land along the Route.
   There are 98 villages in the scope 250 meters from each side of the expressway with 18,300 households and a population of 66,115. The cultivated area is 40,700 mu, among which 21,100 mu is irrigated land and
19,600 mu is nonirrigated land.

The conditions in the different sections are given in Table 3-3-2 and Table 3-3-3.

Table 3-3-3 shows that the per capita farmland is low in the areas along the route, ranging between 0.38 and 1.1 mu. The average works out roundly at 0.61 mu, lower than the province's average (0.65 mu/person). Especially in the sections of Licheng District, Jinjiang County and Nan'an County, where the per capita farmland is below 0.5 mu, the contradiction between more population and less farmland is remarkable. It looks as if that the land along the route is quite precious.

3.3.2 Industry and Agriculture and the Structure of Agriculture, Forestry, Husbandry, Sideline Production and Fishery.

The regions along the proposed expressway is an important rice and fruit base in the southern part of Fujian Province. In the previous years, economic incomes relied mainly on agriculture because industry was underdeveloped. Since the reform and opening to the outside world, the township enterprises have been developing very rapidly. The output value of industry is getting a yearly increasing share of the Gross Output Value of Industry and Agriculture, bringing about great changes in the social-economic structure. Based on the statistic data of 1991, the total output value of industry and agriculture of the 54 administrative villages along the route was RMB 319.59 million yuan, among which RMB 207.51 million yuan came from the output value of industry accounting for 64%. The rest RMB 112.08 million yuan was generated from the output value of agriculture with an industry-agriculture ratio of 1:0.54, compared with 1:2.4 in 1980. However, the output values of industry and agriculture differ greatly in the various sections along the route (See Table 3-3-4). The output value is higher in the corridor of Jinjiang County, Nan'an County and Licheng District. Which is associated with the great development of ceramics and building material industry at the township level in recent years. Though the sections of Tong'an County, Jimei and Xinglin near Xiamen Economic Special Zone see a growth in the output value of industry compared with the precious years, yet agriculture still dominates to some degree at present.

In the economic structure of agriculture, forestry, animal husbandry, sideline production and fishery along the route (See Table 3-3-5), agriculture (farming industry) accounts for 74% of the total output value, indicating that the revenues from the farming industry still remain high. The second comes animal industry, accounting for 12%. Fisheries industry contributes 7% of the total. However, the output value from forestry is very low, amounting to RMB 321,000 yuan only, i.e. 0.7% of the total output value. In some sections, such as Licheng section and Jinjiang Section, the revenues almost come to naught because there is less land with comparatively more people. Because of good land resources, most of the land is used for farming industry and fishery.

2.2.3 The Agriculture Production along the Route

On the whole, first place is given to grain and sugarcane as concerns the agriculture production, which contains a certain ratio of peanuts, fruit (longan) and fresh water cultivation. The outlays of economic activity in agriculture in the sections along the route differ due to the great differences in terrains, soil and water supply. Take Licheng District for example, the culture of rice forms a large
proportion of the area due to its open and flat terrains and good water supply, while there is few non-irrigated crops such as sugarcane and peanuts (See Table 3-3-6). The cultivated area of longan trees along the sections in Jinjiang County and Nan'an County is 346 mu with an annual output of 250,000 jin, lower than the yield of the longan trees of the same tree-age in other sections. All this may be related with the atmospheric pollution caused by the development of industry along the road sections in recent years.

The conditions of agriculture production in the section along the route are given in Table 3-3-6.

3.3.4 Traffic Conditions along the Route
Most of the sections along the expressway are close to the existing Fuzhou-Xiamen Highway, and intersect the existing road at several points, resulting in the convenient traffic. The traffic stream observed at different observation points are given in Table 3-3-7. The highway transport network radiates in all directions to connect the villages and towns along the route. The buses can even reach the interior among Mt. Dapingshan, Mt. Dansushan and Mt. Xiaoyingling, providing a favourable condition for the transportation of materials in the process of construction of the highway, especially the construction of the tunnels.

3.3.5 Cultural Relics and Landscape
There are a lot of cultural relics and scenic spots from Quanzhou to Xiamen. However, no other scenic spots will be impacted except Tongming’er Pass on Mt. Xiaoyingling under which a road tunnel is to be cut. These main scenic spots are located near the interchanges, which benefits tourism.

Among these main scenic spots are:

Quanzhou Scenic Spot:
Quanzhou is a famous historic city in China, its main scenic spots are Kaiyuan Ancient Temple built in AD 686 with a history of 1,000 years, Qingjin Temple built in AD 1009, Mt. Qinmuan in the northern suburb of Quanzhou, Linshan Sacred Tombs in the eastern suburb of Quanzhou in which the third and fourth disciples of Mohammed (c. 570-632), founder of Islam, were buried, and Luoyang Bridge, the beam stone bridge built in 1059. All these scenic spots can be reached by way of Chenzhou Interchange.

Nan’an Scenic Spot:
In this district, there stands Anping Bridge, the earliest beam stone bridge in ancient China, which was built in AD 1138 with a total length of 2250 meters and is under State protection. Longshan Temple, located in Anhai Town, is the originator of over 400 Longshan Temples in Taiwan Province and Zhengchenggang’s (a national hero) Tomb in Nan’an County. It’s very convenient for the tourists to visit these via Puli Interchange.

Xiamen Scenic Spot:
Xiamen is one of the ten picturesque cities in China with a lot of scenic spots such as Gulangyu Island, Nanputuo Temple, Overseas Chinese Village in Jimei and Mt. Yangshishan, etc. Hou’er Interchange will provide the tourists with a quick access to Xiamen to pay a visit to these tourist attractions.

All things considered, Quanzhou-Xiamen Section of the Expressway is beneficial to the development of tourism.
3.4 The Status quo of Environmental Quality

3.4.1 The Status quo of Atmospheric Environment Quality

3.4.1.1 Monitoring of the Status quo of Environment Quality

In order to have a better understanding of the current states of the atmospheric environment quality along the expressway, in June, 1992, the current states of atmospheric environment quality was monitored.

(1) Layout of the monitoring points

On the basis of the features of the route alignment and topography along Quanzhou-Xiamen Section, the necessity and possibility of monitoring points were set up on the vital communications lines, the locations of towns and villages and urban areas in Xiamen, Quanzhou, Tong'an and other places. The sites can be seen in Table 3-4-1 and Fig 4.

(2) Monitoring Program, Time and Methodology

Based on the major atmospheric pollution sources and the main pollutants discharged in the assessment areas, and in combination of project features of the proposed expressway, it was decided that T.S.P.N O., Co.THC and Pb would be monitored.

Measurements were taken, maintaining a period of 5-day measurement in summer so as to make a record of meteorological conditions such as wind direction, wind velocity, air temperature and air pressure. The monitoring programs at different monitoring points are presented in Table 3-4-1. The analytical methods, sampling frequencies and flow amount of various monitoring programs are given in Table 3-4-2.

(3) Results of the Monitoring

260 data secured in the monitoring were put in order and the statistical theory was applied to measure out the instantaneous concentration ranges of various pollutants at different monitoring...
points, daily average concentration range and total mean value. The outcomes are presented in Table 3-4-3.

3.4.1.2 Analysis of the Current States of Atmospheric Environment Quality

(1) Criteria for Evaluation

In the assessment, the criteria of NOx, CO and T.S.P were selected from Class II State Standard stipulated in GB3095-82. (See Table 1-1).

(2) Methodology Applied in the Assessment

The results secured in the monitoring of air quality were analysed as contrasted with the stipulations, expressed in terms of overruns and the rate of overruns.

(3) Analysis of the Results

The fluctuation range of NOx instantaneous values stood between 0.004 mg/N m² and 0.087 mg/N m². The maximum instantaneous value was 0.087 mg/N m² at Luntou monitoring point. The instantaneous values at all monitoring points conformed to Class I State Standard of Atmospheric Environment Quality. The daily average concentration range at the monitoring points along the route varied between 0.004 mg/N m² with a maximum value of 0.051 mg/N m² at Luntou monitoring point, all of which didn't surpass Class II State Standard.

In light of concentration distribution at the monitoring points along the route, there was no obvious regularity, basically reflecting the background level of NOx Contents along the route.

The fluctuation range of T.S.P daily average concentration stood between 0.005 mg/N m² and 0.195 mg/N m² with maximum value of 0.195 mg/N m² at Xindian monitoring point, not exceeding Class I State Standard of Atmospheric Environment Quality.

In the light of planar distribution along the route, T.S.P
concentration at Xindian monitoring point was higher, mainly affected by the chimneys of the villages nearby and the traffic on Quanzhou-Jinjiang Highway. The concentrations at the other monitoring points corresponded to one another. On the whole, TSP contents were low.

The fluctuation range of CO instantaneous values stood between 0.25 mg/N m² and 1.34 mg/N m² with a maximum instantaneous value of 1.34 mg/N m² at Jiwei monitoring point. The instantaneous values at all monitoring points conformed to Class I State Standard. The daily average concentration range at all monitoring points along the route varied between 0.28 mg/N m³ and 0.91 mg/N m³ with a maximum value of 0.91 mg/N m³ at Jiwei monitoring point. However, they didn't surpass Class I State Standard.

In view of the planar distribution along the route, the total mean values at different monitoring points showed no difference and low content. In comparison with Class II State Standard of the environmental goals, there existed some environment capacity.

The fluctuation range of THC instantaneous values was between 0.44 mg/N m² and 4.25 mg/N m² with a maximum value of 4.25 mg/N m² at Dongzhi monitoring point. Since no international standards could be found, the standards of the former Soviet Union were used for reference with the result that all instantaneous values were found in conformity with the standard.

The daily average fluctuation range of Pb stood between 0.19×10⁴ mg/N m³ and 4.58×10⁴ mg/N m³ with a maximum value of 4.58×10⁴ mg/N m³ at Puli monitoring point, far below the Pb standard stipulated State Standard (GB7355-87).

In the light of planar distribution, the total mean values at different monitoring points showed no difference, and there existed some
environment capacity as contrasted with the environmental goals.

To sum up, the atmospheric environment quality in the surveyed areas in which the proposed expressway will be built conforms to Class I State Standard of Atmospheric Environment Quality except for THC. Pb content is also in conformity to State Standard (GB7355-87). THC surpasses, to some extent, the standard when compared with the standard of the former Soviet Union, because there is not a THC standard in China. Even so, the instantaneous values do not exceed the standard concerned. When the atmospheric environment quality at the different monitoring points along the route is compared with the environmental standards, we will find there is great atmospheric environmental capacity to be developed.

3.4.2 The Status quo of Acoustical Environment Quality

3.4.2.1 The Principles Followed in the Investigation and Measurement

Compared with other projects, the investigation of the expressway should be made in a larger area to deal with a wide range of subjects. Besides that, time was pressing and the task heavy. How should the limited time and energy be properly applied to make an overall assessment of current status of the environment? In our work prominence was given to two key points:

1. the Features of the Highway. In accordance with the six interchanges along the proposed road, the whole length of the highway was divided into 7 road sections for investigation and assessment.

2. the Residents Affected. Investigations were made on the residential quarters directly affected by the highway in the seven sections mentioned above on each side of the highway.

(1) Measuring Methods

The measurements were taken in reference to "Measuring Methods of
Environmental Noise in Urban Areas" in "Standard Methods of Environmental Monitor" issued by State Environmental Protection Bureau.
(SEPB) (GB3222-82).

(2) Measuring Devices

Among the equipment used in the measurements were NN-I Automatic Noise-Monitoring Equipment and HE 5931 Vibratory Noise-Measuring Meter. ND-9 Sound-Level Indicator was used as an sound level calibrator.

(3) Measurands

Investigations were made on the around-the-clock ambient noise and traffic noise. The attenuation measurements of traffic noise with the distance on both sides of the highway and the comparative simulation monitoring interchanges were made.

The ambient noise monitoring were carried out in 7 sections respectively:

Around-the-clock measurements of traffic noise were conducted respectively at Hou'an, Luntou and Puli on the existing Fuzhou-Xiamen Highway, and at Yuanqian on Quanzhou-Xiutu Highway, and at Xindian on Quanzhou-Jinjiang Highway, and at Wuling on Jinjiang-Anhai Highway and at Guanlintou on Xiamen-Zhangzhou Highway.

The measurements of attenuation of traffic noise with the distance on both sides of the highway were done at Xifu and Hou'an.

The comparison measurement of ambient noise distribution around the interchange was carried out in the area where the approaches of Jimei Sea-Crossing Bridge stood.

The locations of the monitoring points are presented in Fig 5.

(4) Assessment Indexes and Data Processing

A Weight Sound Pressure Level was used as the basic amount of assessment. Equivalent Sound Level (Leq), statistical sound level (Ln) and
standard deviation \( \delta \) \((n-1)\) were used as assessment indexes. Data processing: \( L_{10}, L_{50}, \) and \( L_{90} \) were expressed by the surpassed A
Noise Level in 10\%, 50\% and 90\% of duration respectively.

\[
\begin{align*}
    L_{eq} &= 10 \log \left( \frac{1}{T} \int_{0}^{T} 10^{\frac{L}{10}} dt \right) = 10 \log \left( \frac{1}{T} \sum_{i=1}^{N} 10^{\frac{L_i}{10}} \right) \\
    \delta_{n-1} &= \sqrt{\frac{1}{N-1} \sum_{i=1}^{n-1} (L_i - \bar{L})^2}
\end{align*}
\]

where: \( L_i \) = sound level detected
\( \bar{L} \) = arithmetic mean value of the sound level detected.
\( n \) = total numbers of sound levels. 100 or 200
\( L_e \) = noise level at the moment \( L \).

3.4.2.2 Results of Monitoring and the Assessment on the Current Status

(1) The Results of Monitoring of Around-the-Clock Ambient Noise along the Route

Based on the field monitoring, we obtained the ambient noise distribution in 7 sections along the expressway, i.e. Xifu-Chenzhou Section; Chenzhou-Wuling Section; Wuling-Puli Section; Puli-Luntou Section; Luntou-Hou'an Section; Hou'an-Tiancuo Section and Tiancuo-Guanlintou Section. Since computers were introduced to carry out automatic monitoring, the artificial errors were thereby picked out. The outcomes of the monitoring are given in Table 3-4-4 and Table 3-4-11.

(2) The Assessment on the Current Status of the Ambient Noise along the Expressway
Traffic noise, dwelling area noise and natural noise constituted main ambient noise along the route with a common feature of a uniform planar space distribution of noise in the zone where monitorings were conducted. If some monitoring points where the traffic noise impacts were remarkable were picked out, the standard deviation of sound levels at the different space points was <2. The environmental areas surveyed along the route are composed of towns and villages. Since China hasn't worked out a standard of environmental noise for the rural areas, and the development concerned have not delimited the functional zones of ambient noise for the rural areas, what we could do is to apply mechanically "Ambient Noise Standard for Urban Areas" (GB3096-82) to our work on the basis of the information concerned (See Table 3-4-12).

The outcomes as compared with State Standard are listed in Table 3-4-13.

A conclusion may be drawn from Table 3-4-13 that the average equivalent sound level in the day differs from that at night by 3-10 dB, 7 dB below the average, which shows that the environmental background is somewhat higher. As contrasted with State Standard, the sound levels in most zones can meet State Standard for Category II Mixed Area. At some monitoring points, the sound levels surpass State Noise Standard at night.

3.4.3 The Assessment of Status quo of Water Quality

3.4.3.1 The Investigation on the Status quo of Water Quality

(1) Cross Sectional Area Distribution

Six sample sections were arranged on the main rivers over which the expressway would cross, i.e., Jinjiang River, Nan'an Channel, Xixi River in Tong'an County and Jiuji River in Nan'an County. The exact locations are given in Fig 6, Fig 7 and Fig 8 and Table 3-4-14.
(2) Monitoring Time and Frequency

The sampling times were designated in May, 1992 and July, 1992 (high-flow period) respectively, two times in a period.

(3) Monitoring Programs

The monitoring programs included PH, SS, Permanganate indexes, BOD\textsubscript{5}, Oils, and Pb, etc.

(4) Methodology

The sample collection, conservation and conveyance were carried out in compliance with "Analytical Approaches of Water and Waste Water Monitoring", 3rd Edition compiled by SEPB. The analytical approaches of various monitoring programs and inferior limit of detection are presented in Table 3-4-15.

(5) The Results of the Monitoring of Status quo of Water Quality

The statistical findings of various cross-sections can be seen in Table 3-4-16.

Analysis was carried out on the basis of the results of monitoring:

PH: The detected scope was between 6.80 and 8.05 in six cross-sections, which meet Class I Surface Water Standard.

Suspended Particles: The detected scope stood between 25.6 mg/L and 217.5 mg/L. The high values were found in Jiu River in Nan'an County and Nanqiu Channel.

Permanganate Indexes: The detected scope was between 1.41 mg/L and 5.96 mg/L. Section 1 in Jinjiang River, Section 2 in Jinjiang River, Section 1 in Xixi River and Section 2 in Xixi River were found to meet Class II Surface Water Standard. Section 1 in Jiu River and Section in Nanqiu Channel were found to meet Class III Water Standard.

BOD\textsubscript{5}: The detected scope ranged between 0.50 mg/L and 3.30 mg/L. All sections conformed to Class I Surface Water Standard.
Oils: The detected scope varied between 0.010 mg/L and 0.180 mg/L in Section 1 in Jinjiang River and Section 2 in Jinjiang River. Section 1 in Xixi River and Section 2 in Xixi River to conform to Class I Surface Water Standard. The water quality of Section 1 in Nanqu Channel and Section 1 in Jiuxi River exceeded Class III Surface Water Standard. The ratio of overruns of Section 1 in Nanqu Channel was 50% and the ratio of overruns of Section 1 in Jiuxi River was 100%.

pb: The detected scope varied between zero mg/L and 0.010 mg/L. All sections was in conformity with Class I Surface Water Standard.

3.4.3.2 The Assessment on the Status quo of Water Quality

(1) Factors in the Assessment

Ph values, permanganate indexes, BODs, Oils and pb were selected for the assessment.

(2) Criteria for Evaluation

The criteria for evaluation was in conformity with "Environmental Quality Standards of Surface Water" (GB3838-88). The standard values of various kinds of factors are presented in Table 3-4-17.

(3) Methodology Applied in the Assessment

The statistics of the outcomes of the monitoring were carried out by use of an arithmetical mean value. The results were directly compared with the criteria stipulated in State Standards (GB3838-88) to draw the conclusions as follows: when the results were smaller than or equal to Class I standard value, they were defined as Class I water quality; when the results were larger than Class I standard value, but smaller than Class II standard value, they were defined as Class II water quality. If the results surpassed Class II standard value, but were smaller than Class III standard, they were defined as Class III water quality. Those results which were larger than Class III standard value, but smaller than
Class IV standard value would be defined as Class IV water quality. When the results exceeded Class IV standard value but were smaller than Class V standard value, they were defined as Class V water quality.

(4) Results of Assessment and Analysis

The results of Assessment may be seen in Table 3-4-18. From the results of the assessment of various items, the conclusions may be drawn as follows: PH value, BOD, and Pb meet Class I water quality standard in all sections; permanganate indexes meet Class II water quality standard in Section 1 in Jinjiang River, Section 2 in Jinjiang River, Section 1 in Xixi River and Section 2 in Xixi River and meet Class III water quality standard in Section 1 in Nanqu Channel and Section 1 Jiuji River. Oils meet Class IV water quality standard in Section 1 in Nanqu Channel and Section 1 in Jiuji River. The water quality of the rest sections is in conformity with Class 1 water quality.

From the results of the assessment in all sections, the water quality in section 2 in Nanqu Channel and Section 1 in Xixi River reaches Class IV standard. The main reason is that the domestic sewage at the upper reaches and the rain wash cause turbidity of water with high content of organic matters and oils which surpass the standard.

3.4.3.3 Investigation on Hydrobiologic

Findings of the Investigation

There were two cross-sections in Jinjiang River with a large amount of phytoplankton among which algae were constant species in \( \beta \)-mesosaprobic zone (\( \beta -ms \)) and the zooplanktons were indicator species in \( \alpha \)-mesosaprobic zones and \( \beta \)-mesosaprobic zones. The pollution level was \( \beta -ms \).

The phytoplanktons in Nanqu Channel are typical indicator species in \( \beta \)-mesosaprobic zones with more indicator species in polysaprobic zones.
when compared with those in other sections. The indicator species of zooplanktons in mesosaprobic zones were comparatively rich, indicating that the organic pollution in Nanqu Channel was severe.

The planktons in the two cross-section in Xixi River of Tong'an County also belonged to those in β-mesosaprobic zones, but were fewer in number when compared with Jinjiang River and Nanqu Channel, indicating that the water bodies were less organically polluted.

The conclusions mentioned above conformed to the findings of investigation on water quality.

3.4.4 The Status quo of Vibration Environment

3.4.4.1 Field of Investigation and Criteria for Evaluation

At present, the status quo of vibration environment along the route results mainly from the road traffic. After the completion of the expressway, the vibration environment will also stem from such vibration. The scope of evaluation covered an area 50 meters from each side of the highway. "Measuring Methods of Vibration Environment for Urban Areas" (GB 10071-88) was adopted for reference while laying down evaluation criteria (See Table 3-4-19).

3.4.4.2 Investigation and Selection of the Monitoring Points

(1) Monitoring of the Status quo of Vibration Environment in Sensitive Areas.

In order to reflect the status quo of vibration environment in residential areas, one monitoring point was set up at Guanlintou, one monitoring point at Putou Village, three monitoring points at Shixian, five monitoring points at Xianxi, five monitoring points at Puli, one monitoring point at Zengcun Village, one around-the-clock monitoring point at Xindian, one daytime monitoring point on the existing Quanzhou-Xiutu Highway and six monitoring points at Xifu to measure the current.
status of vibration environment in sensitive areas. The results are presented in Table 3-4-20.

(2) Monitoring of the current Status of Vibration Environment in Contrast Areas

In order to reflect the vibration background in the zones along the highway, a monitoring point was set up at Neikeng Town in Jinjiang County for comparison.

(3) Monitoring of the current Status of Vibration Environment in Auxiliary Zones.

In order to reflect the relevant zones of the proposed highway and the existing road, the vibration impacts on the existing road were measured. Six monitoring points were arranged in the vertical sections of Fuzhou-Xiamen Highway at Hou'an. Details can be found in Fig 5.

3.4.4.3 Measuring Instruments and Techniques

HE5931 Vibration Noise-Measuring Meter was used for the measurement. As for the measuring techniques, "Measuring Methods of Vibration Environment for Urban Areas" (GB10071-88) was adopted for reference.

The measured amount was plumb-line vibration level and the continuous random vibration measurements were carried out at the different monitoring points. The sampling intervals of vibration environment in sensitive zones and the vibration environment in the auxiliary zones were 15 minutes with a continuous measurement of 1,000s. The sampling intervals of the vibration environment in the contrast areas were 1500s. VL-50, VL-90, VL-95, and VL-n-1! were measured and recorded, among which the value of VL-10 was used as the evaluation amount.

3.4.4.4 Results of Monitoring and the Assessment on the Current Status

The results of the field monitoring can be found in Table 3-4-20 and
Table 3-4-22. The statistical results are presented in Table 3-4-23.

As for the arithmetical mean value of the vibration environment in sensitive zones, $V_{L,10}$ is equal to 74.8 dB in the daytime and 69.2 dB at night, reaching the standard for the mixed areas, commercial areas, industrial areas and the areas on both sides of traffic arteries.

As concerns the vibration background at Neikeng Town, $V_{L,10}$ is equal to 65.9 dB, which meets the standard for residential and education quarters.

The results of vibration monitoring in the auxiliary zone at Hou’an indicate that the current status of vibration in the areas 50 meters from each sides of the existing highway can meet the standard for the areas on both sides of the traffic artery.

IV. The Projection of Environmental Impacts

4.1 The Assessment of Atmospheric Environmental Impacts

4.1.1 The Measurands

(1) Factors in the Assessment:

CO, NO₂ and THC.

(2) Evaluation Criteria and Scope

"Atmospheric Background Quality Standard" (GB3095-82) was adopted for the evaluation criteria. The former Soviet Union’s THC standard was used for reference. Details are presented in Table 1-1.

The scope of the Assessment.

The scope of the assessment covered an area 500 meters from each side of the center line of the expressway and the areas around the interchanges.

(3) Measurands

A. The pollutants to be assessed are CO, NO₂ and THC.

B. In the light of the features of the road sections, the assessment
was carried in 7 sections and around six interchanges.

C. In accordance with the traffic forecast, the assessment were carried out on the basis of 3 base years, i.e. short term (1997), medium term (2005) and long term (2015).

D. In view of the distribution of daily traffic stream, the assessment of the environmental impacts was divided into two parts: the assessment of the environmental impacts of daily average traffic stream (hereinafter referred to as AEIDATS) and the assessment of the environmental impacts of daily traffic stream in peak hours (hereinafter referred to as AEIDTSPH).

E. In reference with the meteorological conditions in the different road sections, the projection was conducted mainly on the representative wind directions, average wind velocity and the most frequent stabilities, laying special stress on adverse polluted meteorological conditions.

4.1.2 The Analysis of Pollution Source Intensity

The main pollution source is the waste gases emitted by the motor vehicles running on the expressway. The main hazardous materials in the waste gases are CO, NO, THC and Pb. The pollutants emitted by motor vehicles vary with automotive types, fuels and running speeds. In accordance with the different projected traffic stream in different road sections in different base years, different automotive types, fuel consumption coefficients at different running speeds, and the contents of oil pollutants, the amount of the pollutants emitted in different road sections and around the interchanges in different base years were respectively estimated. (See Table 4-1-1 and Table 4-1-3)
4.1.3 The Predictive Models and Parameter Selection

(1) The Route Strike of the Road Sections and the Relevant Parameters.

The meteorological conditions vary slightly with the zones in which the road sections are located. The relevant parameters of various road sections are presented in Table 4-1-4.

(2) The Predictive Models and Parameter Selection

Being a busy road, the expressway can be regarded as a continuous line source.

In the light of Gauss Dispersion Model, the continuous point source is equal to the integration of the continuous points source along the length of line source. When the shape of the line source is irregular, the summation process of numerical values can be applied to find the solution.

(1) Summation model of point source (applied to regular, irregular and stereoscopic line source, etc).

In the light of the model of line source adopted by Environmental Protection Agency, U. S. A. the line source is divided into n-1 sections with a length of \( \Delta l \) for each. Its ground concentration formula is as follows:

\[
\frac{QL\Delta L}{u} = \frac{1}{2} \left( f_0 + f_n \right) + \sum_{i=1}^{n-1} f_i
\]

\[
f_i = \frac{1}{n} \exp \left( -\frac{Y^2}{\pi \sigma y \sigma z} \right) \exp \left( -\frac{He^2}{2 \sigma y^2} \right)
\]

where: \( c \) —— the ground concentration at the monitoring point

\((\text{ng/m}^3)\)
CL — the source intensity of line source (mg/s·m.a)

u — background wind velocity on the road (m/s)

He — the average effective height of the line source (m)

\( \delta y \) — horizontal-vertical dispersion parameter (m)

\( \delta z \) — horizontal-vertical dispersion parameter (m)

Since the traffic on the road will bring forth an initial mixed altitude and width, the waste gas emitted by motor vehicles is not regarded as a perfect line source. In order to make a more accurate close-range calculation, the imaginary point source was modified for \( \delta y, \delta z \):

\[
\delta y = \delta y_0 + \delta y,
\]

\[
\delta z = \delta z_0 + \delta z,
\]

In the formula, the initial dispersion parameters \( \delta y_0 \) and \( \delta z_0 \) have something to do with such factors as atmospheric stability, traffic stream, background wind direction, wind velocity and width of subgrade.

The ground concentration in sub-stagnant air is therefore:

\[
f(x) = \frac{2}{1.41 \pi^{3/2} \sigma^3} \cdot e^{-\frac{H e^\sigma}{2\sigma x^2}}
\]

(2) When the wind direction runs at right angle with the line source:

When the road is long enough, it can be regarded as an unlimited line source. When the wind direction makes a right angle with the unlimited line source, the ground concentration is therefore:
\[ C(x,0,0) = \frac{2}{\pi} \frac{1/L}{Q \sigma z(x)} \]

Its concentration has nothing to do with the cross-wind direction.

(3) When the wind direction is in parallel with the line source.

When the unlimited line source is in parallel with the wind direction, its ground concentration is therefore:

\[ C(y,0,0) = \frac{1}{\langle 2\pi \rangle^q} \frac{Q L}{\sigma z(r)} \]

where:

\[ r = \sqrt{y^2 + \frac{B^2}{\sigma^2}} \]

\[ B = \sigma \sqrt{1/\pi} \]

Its concentration bears no relationship with the down-wind direction.

(4) When the wind direction makes an arbitrary cut-angle with the line source:

When the wind direction and the line source form an cut angle of \( \Phi \), its concentration is therefore:

\[ \Phi = \frac{2}{\sigma} \left[ C(x,0,0) \sin \Phi \right] + \left[ C(y,0,0) \cos \Phi \right] \]

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(5) The Selection Relevant Model Parameters

Dispersion Parameter.

In combination with the dispersion parameter rule acquired in field investigations at Shuitou Town by use of triaxial wind velocity meters and the topographic features of different road sections, the rational upgrading modification of the dispersion parameter was made on the basis of ground dispersion parameters in the plain recommended by State Standard (GB/T13201-91).

In the light of the highway technical parameters and the results of the field monitoring by the department concerned on the basis of their experience, the initial dispersion is as follows:

\[ \delta_{20} = 1.9 \quad \delta_{yo} = 5.5 \]

Since the wind velocities differ in the different sections and the wind velocity information provided by the meteorological observatories is the data of wind velocity 10 meters above the ground, such data should be subject to being modified to the wind speed on the pavement according to the average wind velocities at the elevations where the meteorological stations stand.

4.1.4 The Projection of the Atmospheric Environmental Impacts

(1) The Analysis of the Atmospheric Environmental Impacts in Construction Phase.

Excavation, loading, filling operations and flying dust constitute the dust source in the construction phase.

In the dry and hot seasons, such operations will produce great
amount of flying dust, exerting influence mainly on the neighboring areas near the construction sites, especially on the constructors.

The fume from the bitumen heating in the construction, a kind of hazardous gas with awful smell, which contains 3, 4 benzopyrene, will do severe harm to the health of people. For the benefit of the people's health, the bitumen heating plants should be kept far away from the residential quarters, namely, 1,000 meters away from towns and villages. Upwind heating should be prohibited.

(2) The Projection of the atmospheric environmental Impacts in the Operation Phase.

In the light of the highway types and road sections, the projections were made for 7 sections and 6 interchanges. If the forecasts for all sections, interchanges, different base years, different pollutants and statistical amounts and various meteorological conditions should be made, the quantity of work should be tremendous, at the same time unnecessary. In order to elucidate the actual situations, analysis of the road sections, interchanges and the emission of the pollutants were carried out. In combination of the features of the polluted meteorological conditions and locations of the road sections and interchanges, 3 road sections and 3 interchanges were selected for projection, i.e. Xifu-Chenzhou Section (near Quanzhou), Puli-Maxiang Section (with maximum traffic stream), Hou'an-Tiancuo Section (in the southern part of the highway), Luntou Interchange (with maximum traffic stream) and Puli Interchange. The analysis of the results of the projections read as follows:

The Features of the Pollution Concentration Profile along the Highway.

The projection of the pollutants shows that the concentration
distribution has something to do with the height of the road from the ground and meteorological conditions.

When the pavement of the highway is slightly higher than the ground, for instance, Pull-Haxiang Section which on the average 1 meter higher than the ground. The maximum concentration values are always detected near the highway and decrease by degrees with the distance from the highway (See Table 4-1-5 and Fig 5 (Pull-Haxiang Section)). When the pavement of the highway is much higher than the ground, for example, Xifu-Chenzhou Section which on the average .6 meters from the ground. The maximum concentration value can be detected about 150 meters from the road side, but decrease gradually with the increase of distance from the highway (See Table 4-1-7 and Fig 11).

When unstable, the maximum concentration can be detected near the highway, for example, Xifu-Chenzhou Section where the maximum concentration of B Stability is measured about 100 meters from the road (See Table 4-1-6 and Fig 10). The maximum concentration of D Stability is detected about 150 meters from the road side (See Table 4-1-7 and Fig 11) and the maximum concentration of E Stability will be found about 250 meters from the road side (See Table 4-1-8 and Fig 12).

The concentration distribution along the route depends on the angle at which the wind direction and road cross. Regardless of the angle, the concentration near the highway under the lee of the wind is higher than that in the places far away from the road. However, analysis should be pushed further by taking such factors into consideration as the height from the pavement of the road to the ground and the atmospheric stability. On the whole, under unstable conditions, the concentration values near the highway at a great cut angle is greater than those in stable conditions while the concentration values under stable conditions...
near the highway at a small cut angle are greater than those in unstable conditions. Under otherwise identical conditions, the greater the wind velocity, the smaller the concentration values (See Table 4-1-9, table 4-1-10 and Table 4-1-11).

(3) Short-Term Forecast (1997)

It is predicted that a little amount of pollutants will be discharged in the near future due to the limited traffic stream in the road section. It is thus concluded that the pollutant concentrations in the road sections and around the interchanges will have a limited increment in the environment.

When the wind direction cuts the highway at a right angle, the various pollutant concentration increment under the action of different wind velocities and various kinds of stabilities is therefore:

In Guokeng-Chenzhou Section, the daily average CO concentration is below 0.140 mg/m³. NOx concentration is below 0.020 mg/m³ and THC concentration is no more than 0.007 mg/m³. In the peak hours, CO concentration is below 0.330 mg/m³, NOx concentration is below 0.050 mg/m³, and THC concentration is below 0.020 mg/m³. In Fuli-Haxiang Section, the daily mean CO concentration was below 0.270 mg/m³, NOx concentration was below 0.040 mg/m³, and THC concentration was below 0.015 mg/m³. In the peak hour, CO concentration was below 0.950 mg/m³, NOx concentration is below 0.090 mg/m³, and THC concentration is kept under 0.040 mg/m³.

It is thus evident that the various pollutants exerted by Chenzhou-Xiamen Expressway will produce less influence on the environment, and the instantaneous increments will not surpass Class 1 Air Quality Standard.

(4) Medium-Term Forecast (2005)

It is predicted that the various pollutants concentrations along the
route will increase with the growth of traffic stream in the medium term.

When the wind direction crosses the road sections at a right angle, the various pollutants, under the action of different wind velocities and various stabilities are therefore:

The daily average CO concentration in Xifu-Chenzhou Section is below 0.460 mg/m³. NOx concentration is below 0.070 mg/m³ and THC concentration is below 0.025 mg/m³. In the peak hours, CO concentration is below 1.10 mg/m³, the maximum values of NOx concentration in the breeze (u=1m/s) will reach 0.155 mg/m³ and be detected within 100 meters from the highway under neutral and unstable condition and within 100 meters to 200 meters from the highway under stable conditions. In the other places, NOx concentration is below 0.150 mg/m³. The measurement of THC concentration has been taken and found that it is no more than 0.060 mg/m³. The daily average CO concentration in Puli-Maxians Section is below 0.560 mg/m³. NOx concentration is below 0.080 mg/m³ and THC concentration is below 0.030 mg/m³. In the peak hours, CO concentration will be kept under 1.33 mg/m³, the maximum value of NOx concentration in the breeze (u=1m/s) will reach 0.188 mg/m³ and is above 0.15 mg/m³ in neutral and unstable conditions within 100 meters from the road side. Under stable conditions, it can be detected within 400 meters from the road side. Generally speaking, NOx concentration is always below 0.100 mg/m³ in other cases, THC concentration is below 0.007 mg/m³. It is thus clear that only in the breeze (u=1m/s) will NOx concentration during the rush hours surpass Class II standard (0.15 mg/m³) in medium term. NOx concentration under the action of other wind velocities and other pollutants will not surpass the standard.
The Concentration Profile around the Interchanges is as follows:

Chenzhou Interchange: Under condition of D Stability and Stagnant air, the daily average surrounding CO concentration is below 3.10 mg/m³. NOx concentration is above 0.15 mg/m³ within an area 100-150 meters around the interchange. The maximum value of NOx concentration is above 0.40 mg/m³ in the lower sections of the interchange, while THC concentration is below 0.18 mg/m³ in the lower sections of the interchange. In the peak hours, the maximum CO concentration detected in the lower sections of the interchange is no more than 7.40 mg/m³. NOx concentration is below 0.30 mg/m³ within an area 150-200 meters around the interchange and above 0.90 mg/m³ in the lower sections of the interchange. The maximum THC concentration is below 0.40 mg/m³ in the lower sections of the interchange. In the peak hours, when the wind direction cuts the highway at a right angle with a wind velocity of 2.5 m/s, the maximum CO concentration around the interchange is no more than 2.10 mg/m³ under conditions of D stability. Only in the sections where the pavement parallels the wind direction is NOx concentration above 0.15 mg/m³, while in other sections, NOx concentration is below 0.15 mg/m³. And THC concentration, on the whole, is no more than 0.10 mg/m³. It's thus evident that in the medium term, generally speaking, various pollutants around the interchange will not exceed Class II Standard in the normal meteorological conditions. However, in the stagnant air, the pollutants will surpass Class II Standard to some extent around the interchange. In the peak hour, the scope in which the pollutants surpass Class II Standard will reach 150-200 meters.

Luntou Interchange: Under conditions of stagnant air and D stability, the daily average CO concentration will reach 4.00 mg/m³ in the expressway road sections of the interchange. Within 200 meters around the
interchange. NOx concentration is above 0.15 mg/m² and above 0.30 mg/m² within 50 meters around the interchange. THC concentration is below 0.25 mg/m². In the peak hours, CO concentration is above 0.25 mg/m², surpassing Class II Standard in the expressway road sections of the interchange. In other parts of the interchange, CO concentration will not surpass Class II Standard. NOx concentration is above 0.30 mg/m² within 300 meters around the interchange, that is to say, NOx concentration exceeds Class III Standard. The maximum THC concentration is below 0.60 mg/m². In the peak hours, when the wind direction crosses the highway at a right angle with a wind velocity of 2.0 m/s, the maximum CO concentration around the interchange is no more than 2.6 mg/m² under conditions of D stability. NOx concentration is above 0.15 mg/m² in the some local places of lee side. In most places of the interchange, NOx concentration is below 0.15 mg/m². THC concentration is below 0.14 mg/m². It's thus evident that in the peak hours, NOx concentration will surpass Class II Standard in some local parts of the interchange in normal meteorological conditions in the medium term. However, NOx concentration will exceed Class II Standard in a large scope under conditions of stagnant air and surpass Class III Standard in a scope of 300 meters in the peak hours.

Puli interchange: Its pollutants source is quite similar to Luntou Interchange. What it differs from Luntou Interchange is in shape, so is the concentration distribution. However, the regularity of the concentration distribution is basically similar. Under conditions of stagnant air, NOx concentration will surpass Class II Standard. In the normal meteorological conditions, NOx concentration will surpass Class II standard in some local parts of the interchange in the peak hours.

(5) Long Term Forecast (2015)
The pollutant concentration along the route will increase remarkably with the noticeable growth of traffic stream in the future.

When the wind direction cuts the road sections at a right angle, the pollutant distribution under conditions of different wind velocities and stabilities will be as follow:

In Quokang-Chenzhou Section, the daily average CO concentration is below 0.85 mg/m². NOx concentration is below 0.13 mg/m² and THC concentration is under 0.05 mg/m². In the peak hours, CO concentration is no more than 2.10 mg/m². NOx concentration in the breeze (u=1m/s) exceeds 0.15 mg/m², and its territorial scope will expand with the growth of the stabilities. Under conditions of F Stability, such a territorial scope will reach over 500 meters. In Pulimaxiang Section, the daily average CO concentration will not below 1.10 mg/m². NOx concentration is below 0.15 mg/m². THC concentration is below 0.06 mg/m². In the peak hours, CO concentration is below 2.50 mg/m². In some local places, NOx concentration in the breeze (u=1m/s) is above 0.30 mg/m² and above 0.15 mg/m² with an increasing distance. Moreover, when the wind velocity is 2m/s, NOx concentration is above 0.15 mg/m².

As concerns THC concentration, it is below 0.13 mg/m². The daily average pollutant concentrations in Hou’an-Tianxue Section is similar to those in Pulimaxiang Section. NOx concentration will surpass Class II Standard in the breeze near the highway. In the peak hours, NOx concentration will exceed Class III Standard in some local places. It’s thus clear that NOx concentration, under conditions of the breeze, will surpass Class II Standard in the daytime within 100-200 meters along both sides of highway and exceed Class III Standard within 100 meters.

The concentration distributions around the Interchanges read as follows:
Chenzhou Interchange: Under conditions of stagnant air and D stability, the daily average surrounding CO concentration will be below 8.00 mg/m². NOx concentration surpass Class II Standard within 300 meters and Class III Standard within 150 meters. THC concentration is below 0.30 mg/m². In the peak hours, CO concentration is above 10.00 mg/m² in the lower sections of the interchange. THC concentration is below 2.00 mg/m². NOx concentration surpass Class II Standard in the scope of projection network and most of the NOx concentration exceeds Class III Standard. In the peak hours, when the wind direction crosses the highway at a right angle with a wind velocity of 2.5 m/s, CO concentration under conditions of D stability around the interchange is below 3.5 mg/m². NOx concentration surpass Class II Standard within about 100 meters of lee side, and THC concentration is below 0.18 mg/m².

It's thus evident that in 2015, the main pollutants which will exceed the standard are NOx, which surpass remarkably the standard not only in the stagnant air, but also on the lee side in the peak hours.

Luntou Interchange: Under conditions of stagnant air and D stability, the daily average CO concentration is below 8.50 mg/m². NOx concentration surpass Class II Standard in the scope of projection network. The area in which NOx concentration exceeds Class III Standard is 250 meters from the interchange. THC concentration is below 0.45 mg/m². In the peak hours, CO concentration exceeds Class II Standard in an area about 50 meters from the interchange. In the scope of projection network, NOx concentration exceeds Class III State Standard. In the case of utmost severity, it will be 7-8 times Class III State Standard. THC concentration is below 1.10 mg/m². In the peak hours, when the wind direction cuts the highway at a right angle with a wind velocity of 2m/s, the maximum CO concentration is no more than 5.00 mg/m². Under
conditions of D stability. NOx concentration exceeds Class II State Standard in the area on the lee, and Class III State Standard in some local places. THC concentration is below 0.25 mg/m³. It’s thus clear that in 2015 the interchange will witness the remarkable overeiling NOx concentration. In the Stagnant air, NOx concentration will surpass State Standard noticeably around the interchange. Even if there is wind, NOx concentration will exceed Class III State Standard in some local places.

The pollutants concentration distribution of Puli Interchange bears a certain similarity to that of Luntou Interchange. NOx concentration surpasses not only State Standard remarkably under conditions of stagnant air, but also Class III State Standard in some local places on the lee in the peak hours.

4.1.5 Analysis of the Projection Outcomes

The above projections show that the increment of various pollutants in the environment and the proper value of the environment will not surpass Class III State Standard within 100 meters from the road and will not exceed Class II State Standard beyond the range of 100 meters in short and medium term. NOx concentration in all road sections will exceed Class II State Standard within 200 meters from the road in the breeze and surpass Class III State Standard within 100 meters from the highway in 2015. CO and THC concentrations will not go beyond Class II State Standard. The interchanges will be more severely polluted as contrasted with the road sections. In the medium term, NOx concentration around the interchange will surpass State Standard in the breeze and stagnant air. Basically speaking, CO and THC concentrations will not go beyond Class II State Standard. In the long term, not only will NOx concentration surpass State Standard in the breeze and stagnant air, but also CO
concentration exceed Class II State Standard in some local places.

On the whole, the pollutants of various kinds will produce limited impact on the atmospheric environment in the short and medium terms due to the open and flat landform, great average wind velocity and good ventilation along the route. However, the areas near the road sides and the interchanges will be noticeably affected by NOx under conditions of the breeze and stagnant air in the long term.

4.1.6 Suggestions

(1) In order to mitigate the impacts of flying dust in the construction phase, the construction sites should be sprinkled with water, especially in dry season.

(2) Asphalt heating should be located 1,000 meters away from the populated areas on the lee side of the wind.

(3) In the operation phase, highway administration should be strengthened to ensure that only clean vehicles are allowed to run on the expressway.

(4) No new residential quarters will be built within 100 meters from each side of the highway.

(5) The interchanges should be located over 200 meters from downtown areas so as to lessen the influence on downtown areas.

4.2 The Projection of Noise and Vibration Environmental Impacts

4.2.1 The Analysis of Noise and Vibration Environmental Impacts at the Construction Stage.

4.2.1.1 The analysis of Noise Nuisance in Construction phase.

(1) Noise Source.

In the period of construction of the expressway, the main equipment which will produce noise comprises graders, rollers, spreaders, generators,
highway hoppers, bulldozers and excavators, etc. Their sound levels range from 70 dB to 105 dB. (See Table 4-2-1)

(2). Impacts and control of Construction Noise

In accordance with the field monitoring and analysis of noise in Environmental Impact Assessment for Beijing-Tianjin-Tanggu Expressway Projection, the impact of the environmental noise in the Construction phase is within 200 meters around the construction sites. Such being the case, it's suggested that the construction activities be prohibited from 22:00 at night to 6:00 next day if any residential quarters located in the areas 200 meters around the construction sites. The installation sites should be rationally arranged for such equipment which will produce great sound levels as the mixing plants, etc. and every effort should be made to keep it away from the residential quarters.

4. 2. 1. 2 The Environmental Impact of the Vibration in the Construction Phase

The utilization of construction plants of various kinds not only produce noise, but also cause vibration. The results of the monitoring conducted by Japan indicate that machinery causing vibration should be at least 20 meters away from the populated areas.

4. 2. 2 The Projection of Environmental Noise Impact at the Stage of Operation

4.2.2.1 The Predictive Model of Traffic Noise on the Expressway

Models of Federal Highway Administration. US (FHWA) are applied. Assuming that the motor vehicles of the same type are running at the same speed on the expressway and there is great traffic stream (N), the vehicle stream on the expressway can be regarded as equally-spaced noncontinuous point source.
Thus, the coefficient of A sound level of the same vehicles at the Observation Point P at 1h is therefore:

\[ L_{eq} = L_{a, \text{max}} + 10 \log \left( \frac{N_i V_i T}{T_i} \right) + 10 L_g (\frac{r_0}{r}) + \Delta S_{13} \]

where:
- \( L_{a, \text{max}} \) — the maximum average A sound level of the vehicle of i type at the point of reference (PO)
- \( T \) — duration of the evaluation, 1 hour
- \( N_i \) — the traffic stream of i type of motor vehicles
- \( V_i \) — the speed of i type of motor vehicles
- \( r_0 \) — the distance from the point of reference to the carriageway
- \( r \) — the distance from the observation Point (Po) to the carriageway
- \( \alpha \) — attenuation factor relative to the absorption of mulch
- \( \Delta S_{13} \) — the increment and decrement of various factors in the noise transmission

The model presents a typical condition of line source. When there is a little traffic stream, the third item in the model is therefore: \( 20 L_g (\frac{r_0}{r}) + 10 L_g (\frac{r_0}{r}) + 10 L_g (\frac{r_0}{r}) \). For this reason, the line source in the daytime is calculated on the basis of the model mentioned above, and the line source at night is calculated according to the following model:
4.2.2.1 The Determination of Parameters in the Model

(1) The Determination of $L_{a \text{max}}$ and $r_0$

(2) $r_0$ represents the distance from the carriageway to the observation point where the measurement of $L_{a \text{max}}$ is taken. In the different experiments, $r_0$ is designated as 7.5 meters, 10.85 meters and 15 meters respectively.

(3) Sampling of $L_{a \text{max}}$ and $r_0$ in the Assessment

In accordance with Engineering Feasibility Study Report and the relevant information, the motor vehicles running on the expressway are divided into 3 groups:

- Large-sized truck: $L_{a \text{max}} = 91.2$ $r_0 = 10.85m$
- Medium-sized truck: $L_{a \text{max}} = 88$ $r_0 = 7.5m$
- Small-sized truck: $L_{a \text{max}} = 82$ $r_0 = 7.5m$

(2) The Determination of $\alpha$ Attenuation Factor of Mulch

The acoustic environment along Quanzhou-Xiamen Expressway Section is a cross between free state and semi-free state and sound waves might be absorbed by the vegetation to some extent. $\alpha$ attenuation factor is, therefore, designated as 0.5.

(3) The Determination of Various Factors in the Noise Transmission

(1) The Gradient of the Road and the Pavement

The gradient of the road and the pavement have something to do with
the noise. In accordance with the engineering design, the maximum gradient of the highway is 2.8%.

In consideration of this adverse factor, the correct value is designated as -0.5 and the correct value for the pavement structure is designated as 0 dB.

2) Acoustical Attenuation of Acoustic Barriers and Structures.

This projection aims at the noise pollution without acoustic barriers. The acoustic barriers for the key road sections will be taken into consideration in the environmental protection measures.

3) The Impacts of Wind Directions, Wind Velocity and Air Absorption on the Noise

Based on the meteorological conditions such as temperature, moisture and air pressure, it is safe to say that the master frequency of sound caused by the expressway will be attenuated in the air by 0.15-0.36 dB (A)/100 meters. Therefore, the air absorption is left out of consideration in the evaluation.

4) The Selection of Highway and Vehicle Parameters

1) The Traffic Stream in the Road Sections (vehicles/hour)

Calculations are carried out on the basis of the statistical findings of daily average traffic stream in 1997, 2000, 2005, 2015 and 201 provided by the design departments. At present, the daytime traffic stream and nighttime traffic stream in the main road sections of Fuzhou-Xiamen Highway is in the proportion of 3:1. After the completion, the expressway will, in the main, accommodate the present traffic stream of Quanzhou-Xiamen Highway. It follows that this proportion is applicable to the expressway. The findings of vehicle stream forecast are given in Table 4-2-3.

2) Roadway Structure
The filled-up grounds along the route will make the pavements higher than the earth’s surface, while cutting sections will be lower than the ground. In addition, there are some viaducts. All these road sections will serve the function of acoustic barriers and most of the road sections in which the residential quarters are located are filled-up ground. Therefore, only the acoustical attenuation of acoustic barriers in the filled-up sections are taken into consideration in the projection. In accordance with Engineering Feasibility Study Report and Engineering Feasibility Study Supplementary Report, the height of the expressway subgrade is 2 m on the average, and the equivalent sound source of the vehicles is 0.5 meters while the monitoring point is 1.2 meters above the ground. Fresnel Coefficient of Reflection:

\[ N = \frac{2(SO + RO - SR)}{\lambda} \]

In accordance with \( N \) value, the extra attenuation is calculated by table look-up (TLU) (\( f \) is 486 Hz, \( \lambda \) is 0.7 meters) or on the basis of the following equation:
(2 N = )^∞
D = 20 Ls
\frac{1}{5} \log h (2 N = )^∞

4) The Selection of the Running Speed
In consideration of great running speed and noise impact during the operation phase, the running speed in the projection is 100 km/h.

5) The Distance from the Road Side to the Carriageway
In the design, the width of the highway is 28 meters, with two carriageways (2×7.5 meters), the medium strip is 4.5 meters. With this in mind, the distance between the two carriageways and the road sides (L) is designated as 7 meters and 19 meters respectively.

4.2.2.3 The Forecast of the Traffic Noise.
Calculations are carried out by inputting daytime and nighttime vehicle stream in the different road sections in the different years and the distance (ro) between the maximum average sound levels of various vehicles and the point of reference (r o), as well as various parameters into the computer to obtain the sound levels 10M, 20M, 40M, 60M, 80M, 120M, 150M and 180M respectively from the road sides.

The findings of the traffic noise were overlapped according to the following equation:

\[ L_{1} = 10 \log \left( \sum_{i=0}^{n-1} \frac{1}{10} \right. \]

\[ \left. + \sum_{i=1}^{n} \frac{1}{10} \right) ^{i-1} \]
Nighttime traffic noise level is calculated in the same way based on nighttime model.

\[
L_2=10\log(\sum_{i=1}^3 \frac{L_i}{10} + \sum_{j=1}^3 \frac{L_j}{10})
\]

Showing in Table 4-2-4 to 4-2-8, traffic noise level rises annually with the increase of traffic volume. At night, the area in which sound level exceeds standard requirement is larger than that in the daytime, judged by National "Environmental Noise Standard in City Area" which stipulates that roadside sound level in the daytime should be below 70dB and at night below 55dB.

Before 2000, in the area within 20-30 metres from the road, nighttime sound level exceeds national standard. After 2000, it will extend to 30-40 metres and by the year 2015 up to 50 metres. In 2015 daytime sound level will also go beyond the standard within 30 metres from the road.

4.2.2.4 prediction of interchange noise impact

The results of noise testing in the vicinity of bridge approach of Jimei Interchange are as follows.

average equivalent sound level:
below the bridge: 72.3dB;
50 metres away from the bridge: 64dB;
200 metres away from the bridge: reducing to environment background value.

The above prediction value can be used in assessment. The protection distance of interchange is 50 metres.
4.2.2.4 noise impact of roadside sensitive spot

There are 26 noise-sensitive residential quarters along the route. Noise prediction results with environment background value added by the 2015 are listed in Table 4-2-10. As the table shows, the range of sound level satisfying standard requirement is as follows.

From Xifu to Guokeng: 30 metres outside the road in the daytime and 90 metres at night;

In Yuanqian: 30 metres outside the road in the daytime and 80 metres at night;

In Chezhou: 20 metres outside the road in the daytime and 40 metres at night;

In Xindian Guokeng: 25 metres outside the road in the daytime and 180 metres at night;

In Cidian: 20 metres outside the road in the daytime and some 90 metres at night.

Thus it can be seen that sound level overrunning is rather severe, especially at night.

4.2.3 prediction and impact assessment of environmental vibration

The results of vehicle roadside vibration survey along the Fuzhou-Xiamen Highway are: light vehicle 77dB, large vehicle 86dB, container truck 87dB. This means that vibration has its influence to some extent.

The prediction model is proposed by Construction Ministry of Japan.

\[ L_{10} = a \log(\log Q) + b + ad + ar + ah + af \]

where \( L_{10} \) = prediction value of vibration level (dB),

\[ Q = \text{equivalent traffic volume (veh/500s)} \]

\( ad = \text{correct value considering surface roughness (dB)} \).
af = correct value considering ground vibration frequency,
ab = correct value considering surface elevation,
af = correct value considering distance attenuation (dB).

According to computation results, in sensitive area, within two belts 10 metres wide on both sides of the road, the environmental vibration level exceeds 72 dB of nighttime standard of traffic artery and 75 dB of daytime standard, specified in State Standard 10070-80 "Environmental Vibration Standard in City Area".

4.2.4 suggestions of noise and vibration control

4.2.4.1 noise

1. Emphasis will be given to nighttime noise control. Where conditions permit, households should be moved living in the area where noise intensity is 10 dB above standard.

Noise abatement measures should be adopted in all sound intensity overranging areas.

2. Noise control is mainly focused on residential quarters. In the area of sound intensity overranging below 10 dB, sound-proof barriers of different height should be built according to actual conditions.

3. Plant trees along the road. It is estimated that a green belt of 15 metres width will reduce sound intensity by 3-5 dB.

4. Set up long-term plan of land use. It should be strictly forbidden to build new noise sensitive spot in the area of high acoustic level based on prediction of 2015.

5. Residents living in the belt within 30 metres from the road should be displaced or protected by sound-proof wall. Villages need moving or protection of sound-proof wall are listed in Table 4-2-12.

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4.2.4.2 vibration

Noise always follows vibration. Generally speaking, if noise meets requirement, vibration will also satisfy regulation. Keep road and vehicle in good maintenance to reduce vibration. In some areas which need special peace and quiet, measures like setting up vibration isolation ditch may be taken.

4.3 forecast of environmental impact of soil erosion

4.3.1 status quo of soil erosion along the route

According to field investigation and data provided by related County Offices of Water and Soil, there exit no large areas of soil erosion or intensive erosion in the zone along the expressway route. Basically no soil erosion occurs in the agricultural cultivating area of smooth terrain. In light rolling and terrace area, farmers attach importance on water and soil conservation, build terraced fields on the mountain slope by cutting protruding parts and filling dents, raise replant index to increase surface coverage, so the soil erosion in this area is not obvious or at a low degree if any. Only in some hills and mountain areas such as Daping Mountain, Xiaoyingling Ridge, Damao Mountain, due to large gradient, poor vegetation coverage and large area of surface exposure ensuing from quarrying, soil erosion is relatively severe in the form of surface erosion and gully erosion. Such area constitutes a small per cent of the zone along the expressway. So generally speaking, roadside soil erosion is not serious, and in most sections not obvious or at a low degree.

4.3.2 analysis of cause of soil erosion following highway construction
1. rainfall

Rainfall, the power source of water erosion in soil, is an important factor affecting soil and water loss in the zone along the Expressway. Given in Table 3-2-3, 3-2-4, precipitation in the counties and cities along the expressway route is between 1000mm and 1500mm, but its distribution is uneven among seasons with 80 per cent concentrating in the period from April to September and the dry season from October to next March accounting for 20 per cent. So the construction in the period from April to September will cause large water and soil loss.

2. vegetation

As a positive factor resisting soil erosion, vegetation plays a role in holding back rain water to lessen rainbeat force and improving soil structure to increase soil permeability. The vegetation and its coverage will determine the amount of soil loss to a great extent.

The expressway construction will clear vegetation by cutting trees, eliminating bushes and sods in right-of-way and soil bank. This will result in direct soil exposure of construction area, thus increasing the possibility of soil and water loss.

3. topography

Topography is an important factor affecting soil and water loss. Within construction area, filling and cutting of subgrade will change original microtopography, thus causing easy soil and water loss. For example, most of borrow areas along the route, whose topography is light rolling and terrace, have been built into terraced fields, so the soil and water loss is small. But when the construction starts, the topography will be destroyed, resulting in loose soil surface and
efflorescence subject to runoff action and flowing away in consequence.

4. soil

Soil is the target of rainfall wash, whose intrinsic attributes such as soil texture and organic content are high correlative to soil erosivity. Normally soil of high organic content has good structure and permeability with low surface runoff, so the soil and water loss is small. In order to know the soil regime along the route, we collected eleven profiles of soil samples in major road sections, whose location are identified in Figure 15. The analyzing results of physical chemical properties are listed in Table 4-3-1.

As the table shows, in the same profile, the soil surface, Horizon A, has a low clay content and distinctly high organic content, suggesting good erosion resistance of the surface; the bed (Horizon B+C), on the contrary, has a low organic content, high clay content and poor permeability, subject to surface runoff following rainfall. When the topsoil is stripped during construction period, the exposing bed will be fall a prey to soil erosion.

4.3.3 analysis of sensitive section or area of soil erosion along the route

Differences in geological, geomorphological condition, cutting depth and embankment height will led to obvious variation of soil and water loss along the route.

1. cutting section

In cutting section, soil erosion mainly occurs in the slope front. The deeper the cutting is, the more gradient the slope is and the more vulnerable the soil is to erosion. According the construction
investigation of the like, it is easy to take measures such as protection slope or sodding to control soil erosion in the section whose cutting depth is below 8 metres and slope front is small; but as for those sections whose cutting depth is above 10 metres, special protection measures should be taken to avoid large amount of soil washing ensuing from slide. According to the design, there are seventeen sections with cutting depth above 10 metres. The location and volume of cut are listed in Table 4-3-2.

As pointed out in the table, there are seven cuttings with depth above 10 metres, are located at entrance or exit portal of the tunnel. These areas are of granite hill topography with a shadow weather layer (generally no more than 2m). The cutting slope is mainly composed of stone slope. Soil slope accounts for a small per cent. Soil erosion is small due to a small area which could be eroded. The topographic condition in Ganshi, Houba, Front Mountain of Zheng'an Village is the same as above described, so the construction will not cause too much soil loss. Only in such sections as Gaocuo, Niushan, Kuishanyan, Shaxi, Kangdian, Hunei, soil layer is deeper, so larger area of soil slope will be exposed after cutting. Hence more soil and water loss. In construction attentions must be paid to protect these six sections which are sensitive areas of soil and water loss.

2. filling section

The height of filled embankment of expressway will be 1 to 25 metres. Soil erosion mainly happens in side slope of the embankment. The length of side slope will exceed 14 metres if the height of embankment is above 8 metres. If no protection measure is taken, water and soil
loss, in form of gully erosion, will take place in side slope when it rains. There are 22 places whose filled embankment are more than 8 metres high. (See Table 4-3-3.) In construction, special attentions should be paid to these places which are sensitive areas of water and soil loss.

3. deposit area

The amount of cuts is smaller than that of fills in this expressway construction, so there is no surplus soil on the whole. Only in the construction of Shantou Tunnel and Xiashaxi Tunnel, a special deposit place should be set up for surplus piles. These excess materials are mainly composed of waste rocks with silt accounting a small part. Hence little soil and water loss during piling period.

4. borrow area

Large amount of earth and rock, needed in embankment construction is more than the cuts could supply. Soil will be borrowed from nearby hillocks, which would leave behind an exposing area of weather crust. When it rains, most rain water will change into surface flow, causing large amount of soil and water loss. According to expressway designing data, there are eighteen major borrow areas along the route, among which Niushan Borrow Area is the biggest with an area of 239 mu, and Chitang Borrow Area comes next with an area of 180 mu. (See Table 4-3-4.) These are key soil and water loss areas following expressway construction.

4.3.4 forecast of potential soil erosion amount

It could be easily concluded from the above analysis of soil erosion sensitive area that many parts of high fill section or deep cutting section of expressway are soil erosion sensitive areas. Construction in
these parts will cause soil and water loss. But it only occurs in construction period with a relatively short time and can be roughly controlled after the works complete so long as protection measures in accordance with construction characteristics are taken. The borrow areas are the most sensitive areas, whose features are: large area of exposed soil mass after cutting and soil borrowing; long period of loss; most of exposure being soil bed with low organic content, poor permeability and runoff frequently occurring after rainfall. So borrow area is the primary source of soil and water loss. It is employed as major analytical object in the following forecast of potential soil loss caused by expressway construction.

1. prediction model of soil and water loss
(US Agricultural Department)

\[ A = R \times K \times LS \times C \times P \]

where \( A \) -- erosion intensity, (amount of loss per unit area and time)

\( R \) -- parameter of erosive force,

\( K \) -- soil parameter,

\( LS \) -- topography parameter,

\( C \) -- biology parameter,

\( P \) -- parameter of soil and water conservation.

2. determination of each parameter in the prediction model

(1) erosive force parameter \( R \)

Parameter \( R \) is the index of rainfall erosive force including the impact of runoff. In the area subject to rainfall erosion all the year round, \( R \) depends on monthly mean and yearly mean precipitation.

The following formula is proposed by Wischmeier:
where \( P \) = year precipitation (mm),
\( P_i \) = monthly mean precipitation (mm).

(2) soil parameter \( K \)

soil parameter is also called soil sensitivity to erosion. The bigger \( K \) is, the higher sensitivity is, and the more vulnerable the soil is to erosion. \( K \) hinges on soil grains content (clay grain, silt grain, sand grain) and organic content. The latest calculation formula given by William at International water and Soil Conservation Conference in 1990 is:

\[
K = (0.2 + 0.3 \exp(-0.0256 * \text{SAN} * (1 - \text{SIL}/100))) * (\text{SIL}/(\text{CLA} + \text{SIL}))
\]

\[
* (1 - 0.25C/(C + \exp(3.72 - 2.95)))
\]

\[
* (1 - 0.75SN/(SN + \exp(-5.51 + 22.9SN)))
\]

where SAN = sand grain content %,
SIL = silt grain content %,
CLA = clay grain content %,
C = organic content %,
SN = 1 - SAN/100,

See Table 4-3-1 for the results.

(3) topography parameter \( LS \)

\( LS \) is the function of surface runoff length (eroded slope and its gradient) and gradient.

\[
LS = \left(\frac{A}{22.13}\right)^{0.5} \times (65.41 \sin^2 S + 4.56 \sin S + 0.065)
\]
where $\gamma$ = slope length,
$\delta$ = gradient,
$m$ = slope length index;

- if $\sin\delta > 5\%$, $m = 0.5$,
- $\sin\delta = 3-5\%$, $m = 0.4$,
- $\sin\delta = 1-3\%$, $m = 0.3$,
- $\sin\delta < 1\%$, $m = 0.2$.

(4) biology parameter $C$

$C$, also called plant cover parameter, is decided by plant species and coverage. See Table 4-3-5.

(5) water and soil conservation parameter $P$

$P$, also called erosion control parameter, should adopt such value stipulated as follows. If there is no plant cover in the construction area and the dozer and shovel are directly put into use, $P$ should adopt maximum 1.0; If no water and soil conservation measure is taken or such measure doesn’t produce effect, $P$ also adopts maximum 1.0; Minimum range of $P$ is 0.01.

3. forecast of soil erosion intensity

$A = R \times G \times LS \times C \times P$

Taking Chitang Borrow Area as an example to describe a concrete forecasting process of soil erosion amount.

(1) $R$: This borrow area is located in Jinjiang Section. According to Jinjiang rainfall condition and calculation formula of erosive force $R$, it is 152.57. ($R=152.57$)

(2) $L$: In borrow area the surface to be eroded in the future is soil bed. According to analysis of soil bed sample in this area, the soil
grades of Horizon B+C is: Clay Grain 24.43%, Silt Grain 32.37%, Organic Matter 0.42% (See Table 4-3-1) By calculating the formula proposed by William, L takes 0.28. (K=0.29)

(3) LS: According to construction plan, the gradient of erosion slope caused by cutting and soil borrowing is 4-8%, the average of which is 6%. Erosion slope length is 150m. After calculation, LS=1.49.

(4) C: The vegetation in this area will be destroyed. Hence an exposure area of no plant cover.

C=1.0

(5) P: In this area of no plant cover, soil is directly taken away by shovel, leaving behind a large exposure area. In construction period, it is difficult to take effective measures of instant result to control soil erosion. So in prediction P takes maximum value, namely, P=1.

Integrating above parameters, soil erosion intensity in Chitang Area will be:

\[ A = R \times K \times L \times S \times C \times P \]

\[ = 152.7 \times 0.29 \times 1.49 \times 1 \times 1 \]

\[ = 65.92 \text{ ton/hectare-year} \]

\[ = 4.39 \text{ ton/mu-year} \]

Concrete forecasting process of soil erosion intensity in other borrow areas could not be specified one by one as space forbids. The principle is the same. For detailed results, see Table 4-3-6.

As Table 4-3-6 shows, soil erosion intensity of borrow area along the route is 58.53-167.56 ton/hectare-year, namely 3.90-11.17 ton/mu-year. Pulij Borrow Area takes the first place with an intensity of 11.17 ton/mu-year, followed by Zenglin Borrow Area with an intensity of
10.53 ton/ha-year. The potential soil erosion amount in major borrow areas along the route is:

\[ Q = \sum_{i=1}^{n} A_i \times S_i \]

where \( S_i \) = erosion area, \( A_i \) = erosion intensity, and \( n \) = number of erosion area. Based on Table 4-3-6, \( Q = 6717 \) ton/year.

This value only represents soil loss from borrow areas. In fact, the potential soil erosion in expressway construction should include, besides this, erosion in subgrade construction and deposit area. From above analysis of sensitive section of soil and water erosion, it can be concluded that soil loss in deposit area will not be too much because there builds a dike against soil and most piles are waste rocks with silt accounting for a small part. As for subgrade, there are 28 places are causative of soil erosion, among which 22 are high fill embankment and 6 are deep cutting. From Table 3, Table 4, it is calculated that the amount of cuts and fills in sensitive section is up to 1.1811 million cubic metres. According to construction investigation data of Guangzhou-shenzhen Expressway, erosion amount accounts for 1.6% of cuts and fills, so the potential erosion amount is 24.56 thousand tons taking the unit weight as 1.6. Assuming that construction lasts four years, it will yearly yield 6.140 thousand tons of soil erosion in subgrade construction. Thus it can be seen that soil and water loss caused by the expressway construction is rather serious. During the construction period, soil borrowing together with cutting and filling in subgrade will yield a total loss of 12.857 thousand tons per year, averaging
634.17 tons per kilometre in four years. This will produce an adverse impact on surrounding ecological environment along the route. So, water and soil conservation is of great importance to this expressway construction.

4.3.5 potential impact of soil erosion on ecological environment

1. impact on farmland

Soil and water loss resulting from expressway construction will affect farmland in two ways. First, in the road section across cropland and in borrow area near cropland, silt of rainfall erosion will directly flow into cropland. With slope flattening, most of the silt will deposit, hence a phenomenon that cropland is covered by silt. In Quanzhou Licheng Road Section and in borrow areas of Houren, Shipu, Xiongshan and Niushan, cropland will be difficult to cultivate under this kind of action. The other influence appears in the road sections and borrow areas relatively far from cropland where cropland will not be covered by silt, but small grains of erosion silt will go into farmland in the form of "mud water" following water flow, thus doing harm to the growth of paddy rice.

2. impact on reservoir

There are many reservoirs along the route such as Chaobang Reservoir, Xin'an Reservoir, Shibi Reservoir, Tianma Reservoir. These are far from the road and located up of construction area, so the construction will not affect them.

3. impact on irrigation channel

Irrigation and drainage system has been built in all farmland along the route. When the silt flows into farmland, some of them will...
inevitably deposit in the irrigation channel through water flow, interfering with normal operation of irrigation and drainage system. It should be particularly pointed out that Low Channel and High Channel of Nanqu Channel, located in Jinjiang Road Section at K11+500 and K15+600 respectively, happen to cross the Expressway. With Chitang Borrow Area not far away, this part is subject to soil and water loss. During construction period, it should take measures to prevent silt from entering into channel course so as to ensure that drinking water source and agricultural irrigation of Chendai Town, Qingyang Town and Shishi City will not be affected.

4.3.6 measures and suggestions

1. measures for water and soil conversation project

(1) drainage and diversion measures

In construction side gutter, top gutter and underground drain can on the one hand, drain water and one the other hand, reduce washing against side slope by water flow. So drains should be built first in construction. At the junction of cutting and embankment, underground drain of cutting should channel the water into natural rivers outside construction area to minimize water accumulation in embankment which will intensify soil erosion. In addition, in all irrigation channels across the route, bridge and culvert or other over-water buildings should be set up to ensure free flow of irrigation water and to prevent silt from going into channels.

(2) measures for construction in rainy season

The rainy season of the area where expressway goes through is from April to September. Soil and water loss mainly occurs in this period, so
the following points should be clearly defined in construction specifications to minimize soil and water loss in the rainy season as much as possible.

A. Construction unit should contact with meteorology department when necessary to know the time and characteristics of rainstorm in advance, so as to compact loose earth already paved or filled before rainfall.

B. In rainy season, try to use the method of "cut and transport and pave and compaction" to reduce loose earth in the construction of subgrade.

C. Keep site drainage system in good operation and maintain ditches unblocked in the construction during rainy season.

(3) measures for slope front construction

Some parts of the expressway are of high embankment or deep cutting. According to different construction conditions, such measures as bulkhead, protection wall, and grouted pitching, cooperated with slope sodding, should be put into practice to fix side slope and avoid slope failure. In addition, most of the subgrade across farmland is to be constructed into high filled embankment. To avoid soil and water loss affecting farmland, it is suggested to put sand bags and stones on the slope toe, which could fix slope toe and on the other hand, hold back sands from slope front.

(4) protection measures in borrow area

As above mentioned, with a large exposure area and long erosion period, borrow area is major area of soil and water loss in expressway construction. It is suggested to take following measures:

A. Set up drains on both sides of borrow areas already designed to
minimize water-collecting area and soil erosion.

B. Select flat surface for soil borrowing. The slope grade should be strictly limited under 4-8% in accordance with construction design. If the silt and sands have serious impact on ecological environment of lower reaches, sediment settling tank should be built and cleared at regular intervals. If borrow soil is taken from high grade hillock such as Niushan, it is advisable to construct sand barrier in down reaches of borrow area.

C. Adopt reclamation and afforestation measures after taking soil away.

2. biology measures for soil and water conservation

(1) sodding on slope front

Besides construction measures like slope wall, sods should be planted on slope front forming after high filling or deep cutting. The effect will be better if these two measures are combined. Sodding method should vary with different soil strength. If soil in subgrade slope is relatively soft favorable for grass to take foot, it is advisable to spread turfs or spray seeds. If it is tough, hole-planting method will be appropriate.

(2) reclamation and afforestation measures in borrow area

As soon as the expressway construction completes, reclamation and afforestation measures in borrow areas should be put into action to minimize rainfall erosion which could occur all the year round. Before reclamation, soil surface in borrow area should be flattened, side slope trimmed and drains dug to avoid washing. There are two kinds of reclamation, forestry reclamation and agriculture reclamation depending
on local natural economical conditions. Generally speaking, forestry reclamation plays a major role in the borrow areas far from village. In the borrow area being farmland before, construction agriculture reclamation should be applied to.

(3) other measures for water and soil conservation

The above described construction and biology measures are rather effective to avoid soil loss. But during construction period, if such measure have not been put into action in time or have not been put into action, the soil loss caused by a rainstorm will be rather huge. So it is suggested that each construction unit be equipped with certain protection coverings such as straw mats, rice straw and plastic cloth. Before rainstorm, cover the exposure area subject to erosion so as to avoid direct rainfall washing and to minimize soil loss.

4.4 impact of expressway on roadside ecological environment

4.4.1 impact on roadside ecological environment during construction period

4.4.1.1 impact on land utilization

The area through which the expressway passes is the golden costal zone of Fujian Province, in which land is very expensive. 10,587 mu land will be under requisition for right-of-way and other auxiliary buildings. Most of them is fertile agricultural land including irrigated farmland of 4,216 mu, non-irrigated farmland of 4,634 mu, orchard of 129 mu, piscina of 168 mu and hilly land of 871 mu. The annual output of these land is 65.38 million yuan.

4.4.1.2 impact on production, life and inter-relationship of roadside residents
Many roadside residents will be displaced. It is preliminarily estimated that some 372 households, 2053 people living in land requisition area will have to move at the time of site clearing in initial period of construction. At present the houses of these displaced are capacious, 38.4 square metres per capita. In respect of geological location and area, the new land given to them for house building will not likely to fully satisfy them all. Moreover, the construction of expressway will break the residents' old production system and lifestyle. As the expressway is access-controlled, residents in the vicinity can't cross it like ordinary road at their will. Near neighbors will become "estranged". Farmers will have to make a detour to go to their land which is very close to their residence. These all are social problems caused by the construction.

4.4.1.3 impact on roadside drainage system

Complete drainage channels should be set up in low-lying land along the expressway to avoid waterlogging which will do harm to crops like paddy rice. According to present design, the subgrade of expressway in these low-lying lands is constructed in the form of filled embankment, which will inevitably cut off many drainage channels and change the old multi-channel scattered draining into concentrated draining through bridge and culvert. In rainy season waterlogging would likely to occur if draining is blocked. Based on investigation, it is estimated that waterlogging is unlikely to happen in most roadside low-lying section of high embankment only by reason of embankment action. Attention must be paid to two places, one is between K10+750 and K11+500 of Jinjiang Chidian, the other is between K33+800 and K34+400 southwest of Xiwei.
Bridge (in Nan'an County). Up these two places catchment basin is large, precipitation is concentrated and mainly falls in form of rainstorm, so waterlogging is quite likely to emerge as a result of sudden increase of precipitation while bridge and culvert discharging capacity is limited.

4.4.1.4 impact on freshwater aquiculture

Along the route, piscinas have been built to develop fresh water aquiculture in places of many waterheads. According to investigation on both sides within 100 metres from road centerline there are 403 piscinas with an area of 681 mu, of which 168 mu is in expropriation zone and will be destroyed in initial period of construction. Located in the vicinity of road, others although not expropriated will be affected by the construction in following aspects. On the one hand, most of the road sections bypassing these piscinas are high-fill embankment. Erosion soil ensuing from construction in rainy season will shallow piscinas and make water more muddy unfavorable for the growth and generation of fry. On the other hand, wastewater from service facilities coordinated with road construction like vehicle repair station, contains such pollution materials as oil, SS, CODcr, ammonia, nitrogen. If such polluted sewage is discharged into nearby piscinas, water will be polluted and fry poisoned.

4.4.1.5 impact on city planning

Long before the expressway project is proposed, some roadside towns and cities of developed industry such as Quanzhou, Chidian, Cizhao and Shuitou have drawn up a program for town and industry development. The construction of expressway will break down old planning to some degrees, causing some problems. In such sections as may cause contradiction
between expressway construction and city planning, under the condition of not reducing curve radius, it is suggested to shift route direction so that expressway construction will not only not affect or affect to smaller extent but also coordinate with the city planning already drawn up or even begun to implement.

4.4.2 impact on roadside ecological environment during operation period

4.4.2.1 analysis of Pb distribution and contamination in roadside environment

The existing Fuzhou-Xiamen Highway is used for analogous analysis in order to know Pb contamination and its range along the route during operation period of the expressway.

1. researching and analytical method

Select four profiles at Fuzhou-Xiamen Highway (in National Highway 324). The criteria of selection is: far from factories; no roadside tree; and open topography. After field investigation, K185+600 east of Quanzhou City and K206+500 of Jinjiang Cizhao are determined as soil analytical profile of paddy Pb contamination; K226+840 of Nan’an Shuitou and K253+300 of Tong’an Luntou are selected as analytical profile of cane and vegetable Pb contamination. See Table 15 for layout. Soil and plants were sampled in November, 1991, at spots which were in leeward direction vertical to the route and of different distance from the road. In each sampling spot, samples were collected from several sampling points which were about 10 metres away from each other and formed a line parallel to route direction. Then raw samples were mixed, from which analytical samples were screened.
Samples included soil (surface soil 0-25cm), leaf blade of paddy rice, mature grains, cane leaf and vegetable foliage. The preparation of sample and Pb analysis was carried in line with "Environmental Monitoring and Analytical Method", edited by state Environmental Protection Bureau.

2. Analytical results and discussions

Pb concentration in soil, paddy rice, cane leaf and vegetable foliage at different distance along Fuzhou-Xiamen Highway is listed in Table 4-4-1. Showing in the table, Pb concentration is closely correlative to the distance from the road either in soil or in plant samples, on the whole dropping as the distance rises. This characteristic Pb distribution gradient in roadside environment is also testified in studying reports from inland and abroad. But decrement rate varies with distance range. Within 30 metres, Pb concentration in roadside environment changes little with distance. At some outer points, it is even higher. In the area between 30 metres and 50 metres from the road, environment Pb concentration drops quickly as the distance rises. It drops gently 50 metres away.

In the light of soil pollution within 200 metres from the road Pb concentration in two profiles exceeds proposed background value of expressway soil lead content (26.1mg/kg) and within 50 metres it exceeds soil lead background content of Fujian Province (34.9mg/kg), indicating that soil has been contaminated within 200 metres from the road, especially within 50 metres.

In the light of Pb concentration in plant foliage, judged by plant Pb background content of 3.5mg/kg proposed by some specialists, roadside
leaf of cane, paddy and vegetable is contaminated to different degrees. Within 40 metres cane leaf and vegetable foliage are seriously polluted, but as far as paddy rice is concerned, it exceeds background content only in the scope no more than 5 metres from the road. This may be attributed to large area leaf blade of cane and vegetable favorable for retaining Pb sediment. In the light of Pb concentration in edible part, judged by food Pb concentration standard stipulated by World Health Organization (WHO) and China health department, Pb concentration of roadside brown rice exceeds national standard (1mg/kg) within 30 metres and WHO standard (0.3mg/kg) within 50 metres. Within 100 metres from the road, maximum lead content of unwashed vegetables is 1.93mg/kg, far above standard. After washing, it drops greatly, satisfying the requirement of national and WHO standard in the area 50 metres away.

From above analysis, it is concluded that during expressway operation period, at least within 200 metres roadside ecological environment will be polluted by lead in tail gas, especially within 50 metres. Pollution level is relative to distance and plant species, declining as distance increases. Vegetable is more subject to pollution than paddy rice. Pb contamination should be attached due stress in expressway design. It is inadvisable to grow vegetable on both sides of the road within 100 metres and to grow cereal crops within 50 metres.

4.4.2.2 impact of Pb contamination on crop growth during operation period

1. forecast of roadside Pb sediment

Based on expressway designing data, traffic volume of Quanzhou-Xiamen Expressway in 2005 will be 18721-38374 veh/day. Assuming that
gasoline consumption is 15 liters per hundred kilometres and gasoline lead content is 0.13-0.36 g/l, averaging 0.25 g/l. roadside lead pollution source strength is 702.0-1364 g/km d. See Table 4-42.

According to a research report given by Davis in 1973, when gasoline burns, 70 per cent of its lead goes into environment, of which 40-60 per cent deposits on roadside. That is to say only 35 per cent of lead in gasoline will be changed into roadside sediment. Pb sediment will mainly deposit on both sides of the road within 200 metres, thus it can be calculated that annual soil Pb intake is 147.4-303.8 g per mu, averaging 225.8 g. See Table 4-4-2 for sediment in each road section.

2. proposed background content of roadside soil lead

Table 4-4-3 shows the proposed Pb content of surface soil in different soil groups along the expressway route, ranging from 22.3 g to 30.6 g per kilogram with an average of 26.1 g per kilogram. Paddy soil has the highest content followed by crimson soil with the other two groups lower. Compared with soil Pb background content of Fujian Province (34.5 mg/kg), the proposed soil Pb content in Quanzhou-Xiamen Section of Fujian-Xiamen Expressway is not high, indicating no Pb contamination in soil.

3. analysis of Pb contamination impact on crop growth

A. impact of soil Pb contamination on crop growth

Based on the research by Ecology Institute of China Academy of Sciences in 1983-1984, if soil Pb concentration exceeds 100 mg/kg, crops will get injured and stunted. In view of above forecast, on both sides of the road within 200 metres mean Pb sediment is 225.8 g/year-mu. One-mu-land weighs about 226 tons assuming that cultivated layer is 25
centimetres and unit weight is 1.36g per cubic centimetre. After 50 years of operation, not accounting lead transfer, accumulative lead will increase by 49.8mg/kg. With present base content of 28.1mg/kg added, the maximum soil Pb concentration will be 78.07mg/kg, still less than critical value of 100mg/kg harmful to crops. Thus it can be seen that soil Pb contamination will not affect the growth of crop.

B. impact of air Pb contamination on crop growth

As Table 4-4-1 shows, Pb concentration in washed and unwashed vegetable differs greatly, indicating that a large amount of lead in plant foliage comes from polluted air. Pb concentration assumes an obvious gradient distribution with distance as a variable. But at different distances no variation of vegetable growth was found out after site observation. At the time of sampling soil and paddy rice at K185+600 of Fuzhou-Xiamen Highway, we conducted a rice output forming factor survey in paddy fields of similar cultivation practice. (See Table 4-4-4) The conclusion is that although air Pb contamination assumed a gradient distribution varying with distance, there is no sharp difference in respect of rice output forming factor. This means that air Pb contamination has not affected rice growth and output. For the time being, critical value of Pb contamination harmful to crops has not been given yet, but we tend to think that air Pb contamination ensuing from tail gas will not reach the point at which crop growth would be affected.

To sum up, Pb contamination during operation period will not have adverse impact on roadside crop growth but would likely to cause elevated Pb concentration in edible part of crops exceeding standard
provided for by health department, thus doing harm to people's health. Taking this into consideration, it is suggested not to grow vegetable within 10 metres from the road and food crops within 50 metres.

4.4.3 suggestion of measures for relieving expressway influence on ecological environment

4.4.3.1 environmental protection facilities

Being access controlled, Expressway can't be crossed at will like ordinary highway. Sufficient passages should be designed for production and inter-association of people. In present plan, there are 36 grade separations and 169 pedestrian passages, averaging 2.54 per kilometre. These passages can meet the need, but in construction variation or supplementation may also required according to concrete conditions.

4.4.3.2 environmental protection measures in construction

1. The area expressway passing through is high populated but farmland in this area is insufficient and expensive. With high maturity and fertility of soil surface, most part of expropriated land is formerly farmland, orchard, or tea garden. The cultivation layer of 0-20 cm had better be stripped, transferred and piled in the vicinity for the use in planting, sodding and revegetation of borrow area.

2. Construction will cause rather serious water and soil loss. Synchronize cutting, transporting, paving and compacting process in the road section of deep cutting and high embankment. Make sure that no loose earth exists in construction area before rainstorm.

3. Wastewater following construction process such as mixing concrete or washing oil-polluted machine should not be directly discharged into nearby piscinas, channels or water course. Construction slags should not
be abandoned at discretion into ponds or at river bank.

4. In bridge and culvert design, try to preserve original natural channels and water flow and don't cut dimension at will. Special attentions should be paid in the construction of Xiwei Bridge so as not to affect Anping Bridge, the National Protection Unit of Historical Relics.

5. Surplus cuts of tunnel should be piled in deposit area specially designed, around which relevant drains, bridges, or culverts should be set up. In the construction of Xiaoyingling Ridge, pay attention to protect "Tongming'an Mountain Pass" above the tunnel.

4.4.3.3 environmental protection measures during operation period

1. Original plant cover in the land used for subgrade, borrow pits and temporary construction will be destroyed, so planting and sodding should be carried out after the Works complete. Special group should be set up to strengthen the management of tree species for quick recovery of vegetation, which is fundamental measure to control water and soil loss.

2. How to make up for the loss caused by expressway occupying agricultural land is a question worth considering. It is suggested to set aside some land requisition funds to strengthen farmland capital construction, turning low-yield land to high-yield land and increasing the land which could yield in drought and waterlogging season. Meanwhile intensive farming should be introduced to increase agricultural output.

3. In view of the fact that roadside ecological environmental pollution mainly results from tail gas, it is required to remain in advance a space for green belt 20 metres wide on both sides of the road
to relieve Pb contamination. In addition, on account of people's health, it is suggested not to grow vegetable on both sides of the road within 100 metres and not grow food crops within 50 metres. Grow economical crops such as flax, or straw of braiding use in place of them.

4.4.4 suggestions of Greening Project

4.4.4.1 greening target

Some ecological environmentalists point out that highway green area should be no less than 30 per cent of total area of land requisition. Based on this, green area of Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway should be no less than 2833 mu but may vary in different parts. In the section passing through farmland, a space of 20 metres wide should be reserved on both sides of the road to build a green belt for Pb pollution relief. In the section passing through residential quarters, the space 20-30 metres wide should be left for noise-proof green belt. In respect of interchange and station of oil supply and parking, the green area should make up 25 % and 5-10 % of the whole area respectively. In service area it should not be less than 40 square metres per capita.

4.4.4.2 requirements of tree species for Greening Project

1. high acoustic-proof function;
2. good pollution-tolerant and air-purifying ability;
3. being decorative plant and not interfering with environmental sanitation;
4. adaptable to local soil, climate; convenience culture and management.

4.4.4.3 Greening Project

93
1. greening of embankment

In the belt within twenty metres from slope toe of embankment, plant four rows of arbor trees and shrubs five metres away from each other with outside three rows being arbors and the inner one being shrubs.

On side slope of embankment, plant turfs or sow grass seeds to fix subgrade and green road environment.

2. greening of cutting

Soil slope front not paved by stone in the cutting should be made plant-covered. On account of high grade and hard soil texture, it is suggested to use net-planting method. Plant arbor trees near water catch ditches on the top of cutting slope and shrubs along roadside drains.

3. greening of median strip

Median strip is the most important aspect worth of considering in Greening Project. Not only anti-glare effect but landscape should be taken into account to avoid dull and fatigue feelings resulting from stereotyped pattern of surrounding. Bushes should be planted with an interval of 1-2 metres between.

4. Greening Project in filling station, bus stop and service area

In these areas, besides achieving greening target, decorative plant should play a lead. The proportion among arbor, shrub and herb is 1:3:4. Flower bed had better be set up in service area to create for the people resting there a scenery pleasing to both the eye and the mind.

5. design of noise-proof tree belt

It is necessary to build noise-proof tree belt in the living quarter where expressway passes by. Wherever conditions permit (land is sufficient), the width of anti-noise tree belt had better exceed 40
metres; if land use is limited, the width may be reduced to 20 metres, which would also yield good results under the condition that density and arrangement of species of trees meet certain demands. Evergreen arbors should play the lead paired by shrubs with an optimum proportion of 4:1 between them. If the anti-noise tree belt would be less than 20 metres in width, it should be replaced by anti-noise wall covered by green plants.

4.4.5 impact on and protection of wildlife

Expressway construction should comply with state regulations concerning wildlife conservation. Don't arbitrarily capture and kill those wild animals protected by central and local governments.

In densely-populated roadside area of high land utilization ratio, no wildlife or rare birds have been found which need protecting.

4.5 forecast of water environment impact

Emphasis is paid on Jinjiang River, Nanqu Channel, Jiuxi River and Xixi River in the forecast of water environment impact. Other channels along the route will not be discussed in detail hereinafter because they have little impact on environment with small water flow and drying during most of the time except rainy season.

In the area where expressway passes through, reservoirs are located at up reaches of pollutant pick-up rivers and will not be affected by expressway sewage discharge.

4.5.1 analysis of water pollution source

1. analysis of surface runoff pollutant

Surface runoff pollution is relative to such factors as precipitation, raining time, surface width, length of pollutant intake
road, road surface, air pollution level, etc. These are random variables highly unexpected. The analysis is undertaken in accordance with concrete conditions of expressway by combining actual measures with document data as there has been no universally-applied method so far.

Affecting factors of expressway surface runoff are relatively simple and surface pollution regime (pollution type and level) is consistent compared with that of city surface runoff. Precipitation and air pollution regime are affecting factors varying obviously. Generally speaking, surface runoff pollutant grows as precipitation and air pollution load increase and pollutant discharging rate drops if raining time extends. On conservative account, we calculate pollutant carried by surface runoff flow in two situations: daily maximum precipitation and annual mean precipitation.

(1) surface runoff volume

Daily maximum precipitation and annual mean precipitation are given by local meteorological stations. Water-collecting area is based on surface width and road length. Pollutant-intake runoff volume is listed in Table 4-5-1.

(2) concentration range of surface runoff pollutant

Listed in Table 4-5-2, concentration range of water pollutant surface runoff in Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway is obtained by comprehensive analysis of document data and actual measures.

(3) forecast of pollutant intake amount in the river assessed

Prediction formula is

\[ Wi = Q \times Ci \]

where \( Wi \) = amount of pollutant \( i \) in surface runoff.
\[ Q = \text{surface water catchment} \]

\[ C_i = \text{concentration of pollutant } i. \]

See Table 4-5-3 for the calculation results.

2. analysis of pollution source in service area

Crossed by Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway, Puli Living Quarter is about half kilometre away from Jiuxi River of Nan'an County, into which waste water from living quarter will be discharged through sewage disposal plant.

The design of expressway transportation auxiliary facilities has not finished. Having no detailed data regarding the size of living quarter, station for vehicle maintenance and oil supply as well as other auxiliary facilities, it is difficult to estimate accurately the pollution source intensity in Puli Living Quarter. Based on relevant data and experience, the sewage COD discharge is estimated to be 15 k/d. Washing from the station of parking, maintenance and oil supply is main pollution source. Polluted water of high oil content will do harm to environment in particular. Assuming that five vehicles can be washed simultaneously and it takes 15 minutes for each one, two hundred vehicles will be washed in a day of ten hours working period. If each vehicle leaves 35 grams of COD and 20 grams of oil, daily COD and oil discharge will amount to 7 kilograms and 4 kilograms respectively. In addition, station of oil supply and maintenance is also supposed to be washed once a day, generally oil discharge will be 3-6 kg/d and COD 2-4 kg/d.

To sum up, pollution source intensity in Puli Service Quarter is 9-11 kg/d of COD and 1-9 kg/d of oil. (not including accident pollutant)
4.5.2 Prediction model

1. Prediction method of water quality in Jinjiang River and Xixi River of Tong'an County.

The main rivers crossed by Expressway are Jinjiang River and Xixi River of Tong'an County, whose pollutant-intake course is tidal waterway. Affected by sea tides, hydrographical factors of the river change with time periodically. Pollutants carried by water reverberate in the river leading to short time concentration superposition in some parts. Rains will eventually go to rivers through roadside drainage system. Because of scattered discharge, pollutant transverse diffusion is roughly homogeneous. In accordance with hydrographical conditions, one-dimensional water quality dynamic model is used to predict transfer pattern of pollutant.

(1) Basic equation

According to Mass Conservation Law and Newton's Second Law of Motion, with regard to single and straight waterway of no branch, basic equation of motion could be expressed as follows:

A. Equation of Motion (Saint-Venant Equation)

\[
\frac{\partial H}{\partial t} + \frac{1}{B} \frac{\partial Q}{\partial x} = 0 \\
\frac{\partial U}{\partial t} + U \frac{\partial U}{\partial x} + \frac{\partial U}{\partial x} + \frac{U|U|}{C^2 d} = 0
\]

where
H = water level at section x, time t (m),
B = section width (m),
Q = instantaneous water flow (m^2/s),
g = gravity acceleration, and d = section hydraulic radius (m).

Water level, flow and current velocity could be calculated from this Equation of Motion (including Continuity Equation (1) and Euler Equation (2)), whose constrains are:

boundary condition: \( H(i, j) = P(j) \)

and initial condition: \( H(i, 0) = h_i, j = 0; u(i, 0) = u_{ij} = 0. \)

B. calculation equation of concentration field

\[
\frac{\partial c}{\partial t} + \frac{\partial c}{\partial x} = D_x \frac{\partial^2 c}{\partial x^2} + \sum K_i c + S
\]

where:

- \( u \) -- current speed (m/s),
- \( D_x \) -- longitudinal coefficient of dispersion (m/s),
- \( K_i \) -- degradation factor of pollutant,
- \( S \) -- source in the waterway.

(2) solution of mathematical model

Flow field assumes Preissman implicit difference scheme:

\[
\frac{f(X, t)}{\Delta t} \left[ \frac{f_{i+1}^{t+1} - f_i^{t+1}}{\Delta X} + (1 - \theta) \frac{f_{i+1}^t - f_i^t}{\Delta X} \right] + \theta \frac{f_{i+1}^{t+1} - f_i^{t+1}}{\Delta X} + \theta \frac{f_{i+1}^t - f_i^t}{\Delta X}.
\]
where f may represent computational factors such as A, E, V, and \( \Delta x, \Delta t \) is step length of distance and time in numerical computation.

Combined method of iteration is used in the computation of concentration field:

\[
\frac{\phi}{\Delta x} = \frac{f_i - f_{i-1}}{\Delta t} \quad \frac{\phi^2}{\Delta x^2} = \frac{f_{i+1} - 2f_i + f_{i-1}}{\Delta X^2}
\]

First, equation set of motion under constrained conditions is solved to get such characteristic values of hydraulics in each waterway section of tidal estuary as water level \( H \), current speed and other parameters. The equation of motion could be changed into following equation set through difference scheme:

\[
\begin{align*}
H_{i-1}' + a_{i-1} U_{i-1}' &+ b_{i-1} H_i' = R_{i-1} \\
U_{i-1}' + a_i H_i' + b_i U_i' & = R_i
\end{align*}
\]

The coefficient matrix of the equations is tridiagonal matrix, so it could be solved through iterative method.

Then, solve equations of concentration field. Equation (3) could be transferred into difference scheme as follows:

\[
\begin{align*}
\phi_{i-1} + a_i \phi_i + b_i \phi_{i+1} & = R_i
\end{align*}
\]

where \( a', b' \) and Ri are coefficients.
Concentration distribution in each section at any time could be got after solving above equations of concentration field through iterative method.

2. Prediction method of water quality in Jiushijiuxi River of Jinjiang County and JiuXi River of Nan'an County

Hold back by Wuliqiao floodgate, the sea tides will not affect JiuXi River of Nan'an County, the water of which unmixed with sea water is mainly used for agricultural irrigation. The water regime here is relatively stable. Jiushijiuxi River, whose water comes from Nanqu Channel upstream of Jinjiang River, is situated above water inlet of Jinjiang domestic water. Under heavy protection the water regime there is constant. The water flow of Jiushijiuxi River of Jinjiang County and JiuXi River of Nan'an County is small. (the former being 6-8 cubic metres per second, the latter 2-10 cubic metres per second.) Ordinarily they don't empty into the sea except in rainy season when the floodgate is lifted. In such shadow, narrow rivers of small water flow, pollutant is easily to get evenly mingled and hydraulic factors are stable. On account of these, a simple computation model could be used for prediction.

\[
C = \frac{C_w Q_w + C_n Q_n}{Q_w + Q_n}
\]

where \(C\) = concentration after complete mixing (mg/l),

\(C_w\) = wastewater concentration (mg/l),

\(Q_w\) = wastewater flow (m\(^3\)/s),

\(C_n\) = concentration of waste-free water (mg/l).
\[ Q_n = \text{water flow of river (m}^3/\text{l)} \]

Following hypotheses are employed in the application of this model.

a) Pollutant is conservative, nondecomposable, nonsedimentable and nonadsorptive;

b) uniform current speed and stable pollutant discharge;

c) Concentration is even at any point of the section.

It should be noticed that water features in pollutant-intake waterways vary greatly with season. Because the pollutant comes mainly from surface washing in rainy season, water features in prediction model are based upon the values of average year so that they can be closer to actual conditions. In fact precipitation is rather low in dry season. Most water catch of highway is used for irrigation. Highway washing discharged into rivers are little, causing no obvious pollution of the river.

4.5.3 prediction results

1. prediction results of water quality in Jinjiang River

COD, BOD5 and oil are used as assessment factors in the prediction. Maximum and average discharge of surface runoff are listed in Table 4-5-3. Take \( 85 \text{ m}^3/\text{s} \) as water flow.

For the computation results see Table 4-5-4.

2. prediction results of water quality in Xixi River of Tong'an County

COD, BOD5 and oil are major assessment indexes in the prediction. Adopt \( 25 \text{ m}^3/\text{s} \) as water flow. See Table 4-5-3 for the source intensity of surface runoff. Computation results are listed in Table 4-5-5.

3. prediction results of water quality in Jiuxi River of Nan'an
Because waste water from Puli Service Quarter is due to be discharged into Jiuxi River, the source intensity of pollution, listed in Table 4-5-6 should be the sum of surface runoff discharge and sewage discharge of Service Quarter.

Take 3 m³/s as water flow in Jiuxi River of Nan'an County. The concentration increment of pollutant are calculated based on source intensity listed in Table 4-5-6. The results are as follows:

- Maximum: COD: 1.50 mg/l; BOD5: 0.29 mg/l; oil: 0.107 mg/l;
- Average: COD: 0.86 mg/l; BOD5: 0.19 mg/l; oil: 0.09 mg/l;

4. prediction results of water quality in Jiuxi River of Jinjiang County

Take 8 m³/s as water flow.

- Maximum: COD: 0.58 mg/l; BOD5: 0.76 mg/l; oil: 0.009 mg/l;
- Average: COD: 0.21 mg/l; BOD5: 0.38 mg/l; oil: 0.004 mg/l;

4.5.4 conclusions and suggestions

The construction and operation of expressway will produce certain impact on water environment along the route. But because there exists no large water pollution source during operation period and pollutant discharge from surface runoff, the main pollution source, is very low, surface runoff of expressway will contribute little to the concentration increment of pollutant in the rivers. In respect of influential range, pollutant concentration near bridges of expressway is a bit higher, dropping as the distance rises.

The sequence of expressway-caused pollution level of water body in several major rivers are as follows:
Jiuli River of Nan'an County > Xixi River of Tong'an County >
Jinjiang River > Jinshijuxi River of Jinjiang County

More pollution in Jiuli River of Nan'an County can be attributed to
the sewage influx of Pull Service Quarter. Comparatively speaking, oil
pollution is more severe than BOD5 and COD, especially in the sections
near city proper.

In brief, oil is the key factor of influence caused by expressway
on the water quality of nearby rivers.

On account of status quo and prediction of the impact on water
environment, it is proposed to take following measures for pollution
control and relief.

1. Measures for surface runoff control
   (1) In the section of Jiasha Bridge, waste water should be disposed
       before being discharged into Nanqu Channel in order to protect water
       quality of Jinjiang Water Plant.
   (2) In case of accident, discharge conduit should be blocked up for
       emergency disposal.

2. Set up sewage disposal station in service quarter.

3. Sewage in construction camp should be disposed by two-stage
   sewage purifier.
4.6 Public Participation

The report titled by the pre-investment work for the Quanzhou-Xiamen Expressway in smooth progress was announced at the front page of Fujian Daily on May 22, 1991. On June 12, 1991, Fujian Daily published again the news of developing the second inter-province passageway to construct the Fuzhou-Xiamen Expressway, and attached the sketch map of plan for the Fuzhou-Xiamen Expressway. Once again the building of the Expressway was mentioned in the article of ensuring the major project to proceed smoothly by the full force and the united cognition all over the province at Fujian Daily on August 30, 1991. The news that the Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway will be commenced building in the end of this year was published at the first page of Quanzhou Daily on March 22, 1992, and came to every residential area along the route very quickly.

The construction of the Quanzhou-Xiamen Expressway Section has great socio-economic benefits, but it brings about some disadvantageous social problems simultaneously. These disadvantages show mostly at influences of highway alignment on densely populated urban areas and relocation of residents along the route. This kind of relocation is unwilling and results in profound impacts on re-building of social economy and environmental variation. In order to reduce the impacts and to arrange the residential relocation well, the task group organized specially the personnel to have a social investigation to give residents along the way more participant chances.

4.6.1 Panels and Investigation Methods

The Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway starts from Xifu of Quanzhou city, and extends southward to end up in Guanlingtou of...
Xiamen city. With a total length of 81.4 km and the influence population of 5.2433 million, the Quanzhou-Xiamen Section strides over 5 cities and counties, 15 villages and towns of 98 natural hamlets. The highway uses land of 105,877 m² in all, and needs to demolish and relocate 97,205 square metres houses including over 300 households.

With the help of sample surveys, this investigation inquired into 130 households of the villages and towns along the road including 79 households along the route, accounting for 60% or so and 51 relocated families, accounting for about 40%. All investigated people are adults and the masters of families with the age of 20-60, in which the women account for 10%.

The investigation took the forms of individual visit to families and survey meeting, then filled in forms and finally put them in order and made statistics. In view of various reasons, some of items of form were filled in by the filler and some were not. So the statistics about a problem was prepared on the base of the number of people responded to the problem so as to reflect the findings correctly.

4.6.2 Findings

This investigation was divided into five parts given as follows one by one:

1) Popularized rate about the news of Expressway construction:

The popularized rate about the news of Expressway construction is the first link of social public participation. From this investigation, it's clear that most people have known the Expressway to be constructed before the investigation. The popularized rate of the news amounts to 92.9%. Most people were to know the news while prospecting teams took the reconnaissance in 1991. On the contrary, persons are in the minority to learn the news from newspapers and televisions. The investigation shows
that the propaganda and reporting is not enough to introduce the news of Expressway construction to the public, and this work should continue to be strengthened.

(2) The investigation about the function of Expressway on local economic development:

In order to survey the acting of Expressway on local economic development after its completion and traffic-improved situation, we inquired 125 families. The results of investigation indicate that:

a) There is some certain difference between relocated and not-relocated households.

b) Residents along the road, especially far away from the interchanges, think that the Expressway doesn't play important role on local economic development, but mostly benefits to the whole society.

c) It is not obvious for Expressway to improve local traffic condition. The Expressway will be good to the area near the interchange, and it's not convenient for most of local inhabitants.

(3) Impacts on environment

Certainly the construction of Expressway will have impacts on the surrounding environment. Since the geographical position, meteorological phenomena, hydrology and geology are different to every household, what the family is effected is not the same. Because of this fact, the people along the route were inquired.

The impacts of Expressway on environment are divided into two stages: construction period and operating period, and they were investigated respectively.

From the investigation of environmental impact during construction period, the views of relocated and not-relocated families are comparatively identical about noise firstly, then atmospheric vibration
and water quality.

In point of the whole views on Expressway, the relocated families differ farther from not-relocated families because the Expressway influences the interests of relocated families directly.

(4) Attitude to the construction of Expressway

The result of investigation gives supporting rate from people of 59%, random rate of 23% and opposing rate of 18%. This outcome states that supporting people have priority over the opposing persons. Though they know clearly their houses will be demolished, many relocated households still take attitudes of supporting to assist the national construction. This responds the spirit of Chinese people of knowing and considering the whole things.

(5) Investigation about wishes of relocated households

In the eyes of investigation on relocated families, their opinions are more intensive, and their chief misgivings are: a) little relocation compensation cost; b) reduction of house base. They can't build the house on the field allocated by standard as large as on the old base; c) not ideal of relocation spot; d) employment.

The results of investigation indicate that most people are willing to be arranged relocation in the neighborhood, and 18.2% persons wish to be arranged at two sides of the existing Fuzhou-Xiamen highway, which is 2 Km far away. This parts of people want mainly to engage in business. In the investigation, a lot of residents, who are mostly near the alternative route, think the whereabouts of employment is unknown because it isn't sure for them to be needed relocation.

4.6.3 Problems and Suggestions

(1) Located at the intersect point with the Quanzhou-Xiutou highway, Chenzhou interchange is the sole grade-separated junction in Quanzhou
city, and will bring very much conveniences for traffic in Quanzhou city. Since Quanzhou city has very less farmland to be used and is surrounded by mountains in three directions with only eastern land developed, the People's government of Quanzhou city has mapped out this section of the area as a new industrial development zone. For the large land used by the interchange amounting to 250 mu, the contradiction of land contention is certain to occur to the interchange and industrial development.

(2) It's intended to build the flyover in Xiaoyingling district crossing over Xiahouba village, the inhabitants of Batou village react to it very intensively. The Batou village is a new-migrated hamlet at the time of building of Batou reservoir. The residents are afraid that the flyover crossing-over not only results in noise, vibration and vehicle waste gas, but also influences sunlight. It's proposed that the alignment of the recommended flyover should be expounded and proved again, and should pass along the mountain avoiding the village in order to reduce impacts on environment of Xiahouba village.

Since the interchange is set up at Hou'an, where the Tong'an-Xiamen highway intersects the recommended route, vehicles from Xiamen to Quanzhou may move up and down at this interchange, and as the Tong'an-Xiamen road will be reconstructed into Class I highway, the intersecting of vehicles is very smooth and easy. Commonly it's convenient for vehicles to Zhangzhou to run up and down at Guanlingtou, and it's unreasonable to go to Fuzhou or Zhangzhou by Tiancuo because the road is bow-shaped and long. So the Tiancuo interchange is proposed to move to Guanlingtou nearby. This is more reasonable.

The investigation and social visit about the original and alternative routes of Xiamen end section were carried out. The alternative route has great impacts on Tianma Seed Farm. This farm is
state-grade, leanness-style breeding pig farm and provides thousands of stud pigs for over 20 provinces of the country every year. At present the travelling golf course is intended to construct by the sino-foreign jointed loan in this spot. The Expressway passing in the middle or by the edge of Tianma Seed Farm will cause the disadvantageous influences. Therefore, in consideration of environmental impacts, it's more reasonable to take the present route alignment.

(3) In the investigation, though the relocated families along the route have various mentality about the relocations, what they think about commonly is relocation cost and house base. Because the land in the countryside is contracted according to a period of 3 to 5 years, the adjustment of house base is relatively difficult. Particularly the households who have larger houses and house basic fields, worry about the base reducing too much and think it difficult to accept the fact if the house base is allocated according to the standard.

(4) The demolition and relocation is a bigger social problem of Expressway construction. The relocation for part of or the whole village will break up the productive system and living manner of the original residents, so the relocation program isn't only a pure land use and compensation plan. It should be considered wholly and arranged properly. From the beginning it should be emphasised that we should do our best to avoid or reduce the relocation if practicable. The relocation principle is to take up a kind of policy to help the relocated households to recover the productive base, employment requirement and raise the income level. Since the residential features due to Expressway construction is long line, scattered spot, fragmentary distribution and difficult to act under the same program, measures are suited to local conditions in the light of various socio-economic features of districts along the route. It is the local authority departments who organize the relocation and implement the funds to the households.
5. Environmental Management Program

5.1 goal and basis of the Program

5.1.1 environmental management goal of Fuzhou-Xiamen Expressway
Quanzhou-Xiamen Section

General Goal: Through environmental management it is aimed to make expressway construction meet the requirement of "Three Synchronization" policy proposed by the State Council, namely synchronizing plan, development and action of economical development, urban and rural construction, environmental construction. It is also aimed to strive for the consistency of economic benefits, social benefits and environmental benefits, to promote the economical development of Fujian coastal areas, to protect ecological environment along the expressway route, thus creating a beautiful environment and promoting economic take-off in the areas along the route.

5.1.2 basis for environmental management

See section 1.4 for the details.

5.2 organization system of environmental management

5.2.1 government organization for environmental protection
5.3 environmental management during construction period

5.3.1 executor of Environmental Protection Program during construction period

1. designing phase: The designing department should take environmental protection measures into account proposed in the "Environmental Impact Assessment" such as building up acoustical wall to limit influence circle of noise to an area within 30-50 metres from the road or resettling local residents, etc.
Construction unit should organize the examination of environmental protection plan and give comments in time. Environmental protection department should take part in the examination of intensive preliminary design and give their comments on environmental protection measures.

2. bidding phase: Construction unit should propose "Environmental Management Regulations During Construction Period" and make "Environmental Protection Action Plan" a part of bidding documents. The Contractor (construction team) should take environmental protection into consideration in his tender and submit "Environmental Protection Action Plan" after receiving the Letter of Acceptance.

3. environmental management during construction period

A. When construction starts, construction unit should assign certain people for the environmental management and supervision during construction period. The focal point of their work is to prevent soil erosion and to monitor construction noise, dust as well as environmental protection facilities. Duties should be made clear and each road section should be specially assigned a person for full responsibility.

B. When construction starts, the Environmental Protection Bureau should examine and approve the location of borrow area and deposit area and construction schedule. During the construction period, it should examine and supervise the implementation of Environmental Protection Action Plan adopted by each construction team, collect waste-discharging fees, investigate and dispose of accidents resulting in severe soil erosion or pollution and if necessary bring them to law.

C. Each construction team (Contractor) should employ an environmental protection man who will propose the Environmental Protection Action Plan.
of Construction according to the environmental problem of his section and should act, supervise and manage in line with the approved plan. He should organize the disposal of the soil erosion incidents and other pollution accidents and at the same time report to construction unit and local environmental protection department.

4. Acceptance phase: The acceptance of expressway should include such environmental protection facilities as antinoise wall, sewage disposal installation as well as planting, sodding, revegation in borrow and deposit area, water and soil conservation, etc.

The construction unit should organize the pre-acceptance or entrust it to local environmental monitoring station before reporting to the government environmental department for formal acceptance.

5. resettlement: Construction unit should be responsible for examining whether all of the resettlement expenditure is allocated to the household displaced and disposing of those resettlement requirements expressed by the household displaced in time. Local environmental protection department should examine environmental plan of new concentrated living quarter for household displaced.

6. environmental monitoring during construction period

The construction unit should monitor noise, sewage draining and dust emission during construction period, investigate and study ecological impact and provide monitoring data to environmental protection department for examination and supervision.

5.3.2 Environmental Protection Action Plan of Construction

1. plan of water and soil loss prevention

As regards borrow area, deposit area, cutting and embankment, there
should be temporary drainage ditches and measures for water and soil conservation in the construction. Revegetation, exploitation of land, planting and sodding should be put into practice shortly after construction, the location of which should be listed in a table for environmental protection department to examine and supervise.

2. greening plan

Planting and sodding along the expressway route will bring benefits in many ways such as antiglare of median strip, sun screen and shading. In the curve and cross, trees could also guide sight line, acting as vertical factor. More significantly, planting and sodding could beautify environment, add to landscape, extenuate pollution of noise, waste gas and dust.

A. suggestions of greening project

See section 4.4.4.

B. implementation of greening plan

Supervised by construction unit, planting should be carried out when the construction of each section ends rather than the whole way is opened to traffic. The environmental protection department should examine the outcome of greening plan in Acceptance phase.

3. construction noise management

According to analogical investigation, within 50 metres of the site, construction noise exceeds the standard sound value of traffic artery, and within 100 metres it exceeds that of residential area. So construction unit should set up Construction Noise Management Regulation, which forbids construction on the site within 100 metres from the village from 10 pm to 6 am so as not to interfere with the rest.
of local residents in the evening. The implementation of this regulation will be under the supervision of construction unit. If violation occurs, local environmental protection department will collect noise nuisance fees or impose a fine on construction teams.

4. plan of construction dusts and air pollution abatement

A. Large amount of dusts resulting from transportation in temporary road during construction period and construction operations will do harm to constructors and local villagers, so sprinkling should be carried at least four times a day from 9 am to 6 pm in the construction section, temporary road, borrow area, etc. Each Contractor (construction team) should employ sprinkler in this operation which will be examined and supervised by construction unit.

B. Due to severe odor and air pollution, asphalt mixing plant should be placed one kilometre leeward from villages and construction camps. The Contractor should consult with environmental protection department for its location.

5. bridge construction and water quality protection plan

Advanced techniques should be adopted in bridge construction to prevent large quantities of silt from entering into the waters. Construction garbage and greasy wastewater should be strictly prohibited from discharging into the river. It should be particularly pointed out that the Jiasha Bridge above the Nanqu Channel of Jinjiang County is situated up the water intake of Jinjiang Water Plant and within the water source protection area of the water plant. Tender is required to determine the construction team of advanced equipment and technology. Construction wastewater and sewage should be strictly forbidden from
going into the waters. This area will be under focal monitoring and supervision of construction unit.

6. environmental management of construction camp

Each Contractor, in charge of the management and disposal of sewage and garbage in the construction camp, should build sanitary installations like sewage purifier and shower bath, and take health precautions for the constructors. Garbages should be put to concentrated disposal.

The construction unit and local environmental protection bureau should examine and supervise the environmental management of construction camp and will collect sewage charge for the discharge of waste which has not been disposed.

7. construction materials (asphalt, cement, oils, chemical materials, etc.) should be under well storage. It should be strictly guarded against pollution accident caused by such materials going into waters under the lashing and washing of typhoon and torrential rain.

Construction unit and local environmental protection bureau should examine the piling location of these construction materials and propose precaution measures.

8. construction of antinoise wall

Listed in the construction schedule, the antinoise wall should be designed in accordance with the requirement proposed in "Environmental Impact Assessment".

9. construction of Puli Service Quarter

Service quarter of Quanzhou-Xiamen Expressway will be built in the vicinity of Puli Interchange, whose service covers overhaul, oil supply.
business and life. The construction of this area should meet following requirements:

A. The construction program of this area should be in line with overall planning and the construction program of Shuitou Town, Anhai Town drawn up by local governments, and should not interfere with "Wuliqiao Scenic Spot", the major National Protection Unit of Historical Relics. The construction scheme (drawings) should be reviewed and approved by Quanzhou Municipal Environmental Protection Bureau.

B. In order to guarantee water quality of Wuliqiao area, production wastewater and domestic sewage should be put to concentrated disposal to meet the requirement of Class I National Sewage Discharge Standard before being discharged into Jiuji River of Nan'an County. The environmental protection department should supervise sewage disposal.

C. The solid wastes in this area (production and domestic garbage) should have disposal outlet, the piling plan of which should be approved by the environmental protection bureau. It should be strictly prohibited to pile the garbage on the bank or to discharge it into the bay.

D. The greening project should be carried out in line with state requirement. The coverage of green area should exceed thirty per cent in consistent with Wuliqiao Scenic Spot.

All in all, the construction of this area should coordinate with the development of Shuitou and Anhai Town.

5.4 environmental management during operation period

5.4.1 executor of Environmental Management Plan during operation period

When the Expressway is opened to traffic, the Leading Group of
Fuzhou-Xiamen Expressway and its office will be changed into Management Bureau of Fuzhou-Xiamen Expressway who will be responsible for the environmental protection management during operation period. Under the dual leadership of Fujian Provincial Transport Department and Fujian Provincial Environmental Protection Bureau, Expressway Management Bureau will be in charge of routine environmental management, supervision, monitoring as well as disposal of emergency accident. The Environmental Monitoring Station will also be set up under its command.

Local environmental protection bureau will mainly play a role in supervising management, pollution accident disposal and the collection of waste discharge fees.

5.4.2 Environmental Protection Plan in operation period

1. formulation, reviewing, approval and implementation of Expressway Environmental Protection Ordinance

A. To protect roadside environment during the operation period, the Expressway Management Bureau should formulate Environmental Protection Ordinance, the content of which covers: noise and gas emission requirement for the vehicles to be running on the Expressway; no-tooting section; velocity limited section; maintenance and management of roadside green belt and antinoise wall; accident disposal; regular road cleaning; other environmental protection measures; regulations concerning rewards and penalties, etc.

B. Before the expressway is opened to traffic, the ordinance should be reported for review to Fujian Provincial Transport Department and Provincial Environmental Protection Bureau. It will be issued by the Provincial Transport Department.
C. The implementation of ordinance will be under the supervision of Expressway Management Bureau and each management station.

2. To prevent Pb contamination on roadside agricultural products during operation period, local environmental protection bureau should conduct propaganda among the planters, suggesting that within 50 metres from the road such ready-to-eat agricultural products as vegetable, paddy rice and fruit should not be planted and should be substituted with economic crops like jute or trees. As for existing orchards, the green belt barrier should be enlarged during construction period.

3. Road cleaning

Clean road at regular intervals and clear accident leakage in time.

4. Operation and management of environmental protection facilities

All environmental protection facilities that have been built should be put into operation. Each management station should assign a man specially for the routine works of maintenance and management.

The Expressway Management Bureau and local environmental protection bureau should examine and supervise constantly. Local environmental protection bureau will collect sewage charge and impose a fine on those who haven't put their environmental protection facilities (such as sewage disposal installation) into operation or discharge wastes which have not been disposed.

5. The management station should promptly organize people to dispose of, clean and wash fuel leakage or leakage of poisonous, harmful materials following traffic accident and at the same time should report to local and higher environmental protection bureaus those traffic accidents that will possibly cause pollution.
8. routine monitoring and reporting system

The Expressway Monitoring Station should at regular intervals monitor air, water, and noise vibration (monitoring plan and system are explained in Environmental Monitoring Plan) and should report monitoring data to Fujian Provincial Transport Department, local environmental protection bureau and Provincial Environmental Monitoring Central Station.

5.5 Environmental Monitoring and Training Plan

5.5.1 environmental monitoring organization

In Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway, an Environmental Monitoring station should be set up for routine monitoring as well as investigation and monitoring of emergency accident.

Under the leadership of Expressway Management Bureau and guidance of Provincial Environmental Monitoring Central Station in professional work, the Monitoring Station will be assigned certain professionals specializing in air, noise, vibration and water quality monitoring.

5.5.2 equipment of monitoring station

Laboratory: construction area: 300-400 square metres

At the front floor, there should be a set of meteorological instrument and enough space and rooms for air monitoring, aiming at setting up automatic internetwork connection of air monitoring in Fuzhou-Xiamen Expressway if condition permits in the future. It is proposed that four monitoring stations should be built along the route.

Equipment:

- air sampler: 5 sets,
- noise automatic monitoring instrumentation: 2 sets.
vibration monitoring instrumentation: 1 set,
water quality sampler: 2 sets,
laboratory analytical instrument including:
ultraviolet spectrophotometer,
atomic absorption spectrophotometer,
visible spectrophotometer,
CO measuring apparatus, BOD culture vessel, refrigerator,
PH meter, oven, balance, routine glass vessels, medicine, etc.
The 800 thousand yuan of total monitoring investment will be accounted into whole investment budget of construction.

5.5.3 Environmental Monitoring Plan
1. air monitoring
A. layout of sampling spots:
For routine air monitoring in Quanzhou-Xiamen Expressway, five sampling spots should be set up, which are proposed to be located at Quanzhou city proper (Cheuzhou village), Xindian village of Jinjiang City, Puli Interchange of Nan'an County, Hou'an village of Tong'ar County, Houxi Dongzhai village in Jimei District of Xiamen City.

B. monitoring item and analytical method:
monitoring item: NOx, T.S.P., Pb in dust, CO
monitoring method: sampling and analyzing according to "Air, Waste Air Monitoring and Analytical Method", edited by the State Environmental Protection Bureau

C. monitoring frequency: four periods per year in each January, April, July and October, five days each period, in rain-free days, four or five times a day
2. Water Quality Monitoring Plan

A. Section Layout:

- River course up and down Chenzhou Bridge of Quanzhou City (Jinjiang River);
- River course up and down Jiasha Bridge of Jinjiang City (Nanqu Channel);
- River course up Xiwei Bridge of Nan'an County (Jiuxi River);
- River course up Wuliqiao Bridge (down outlet of living quarter) (Jiuxi River of Nan'an County);
- River course up and down Putou Bridge of Tong'an County (Xixi River);
- A sewage outlet in Puli Residential Quarter (pollution source);

Eight sections and one sewage outlet all together.

B. Monitoring Items and Analytical Method

Monitoring items: 7 items including Pb, oils, SS, CODcr, BOD5, Pb and permanganate index.


C. Monitoring Frequency: Two periods each year in overflow season (May-June) and dry season (December-January): Two times each period; once a month in key sector (reaches down Jiasha Bridge and Puli Living Quarter);

3. Monitoring of Soil and Living Beings

A. Monitoring Area and Items

Paddy Rice Zone of Cidian: Monitoring paddy rice and Pb in soil.
Vegetable Zone of Tong'an: monitoring vegetable and Pb in soil
Logan Zone of Jinjiang: monitoring vegetable and Pb in soil

B. monitoring time: once a year, sampling rice and fruits when they are ripe, collecting surface soil sample simultaneously

C. sampling location: about 50 metres away from the border of the Expressway

4. monitoring of noise and vibration

A. monitoring area and its location

Regional noise monitoring and vibration impact monitoring in Chenzhou Village; Regional Noise Monitoring in Xindian-Chadian villages; Noise Monitoring in Puli Interchange (including both sides of the road trunk and its surroundings); Noise Monitoring in Hou'an Interchange of Tong'an County; and roadside villages within 100 metres.

B. monitoring frequency: two times each year, measuring in two periods each time: daytime period (from 6 am to 8 pm) and nighttime period (from 8 pm to 6 am) or measuring continuously and automatically.

5. accident monitoring

If serious traffic accident occurs during expressway operation period, its impact on waters should be tracked and under constant monitoring.

measuring items: oils and major accident pollutant

6. environmental monitoring during construction period

A. noise monitoring during construction period

The monitoring should be carried in line with State Standard GB1234 "Noise Measuring Method for Construction Site". Sensitive areas and Quanzhou City Proper (nearby Chenzhou) should be monitored once a month.
B. air monitoring during construction period

Asphalt mixing plant is the major pollution source during construction period, whose impact on villages should be monitored at regular intervals. At sensitive spots and in the section arousing much mass complaints, the influence of construction road dusts on villages should be monitored, which will provide data for the Management Bureau to manage and supervise the implementation of Environmental Protection Action Plan.

C. water quality monitoring during construction period

In the area of soil erosion, particularly the river course down Jiasha Bridge (which is up water intake of Jinjiang Water Plant), the monitoring of suspended solids (silt) should be carried out once a month until the construction ends. Monitoring items are oils, COD, suspended solids, etc. The results of monitoring should be reported to Jinjiang Municipal Environmental Protection Bureau in time.

5.5.4 Training Plan

Listed in Environmental Management Plan, the training of Environmental Management personnel should be a combination of domestic training and training abroad.

1. training content: environmental consciousness training for the leaders of expressway environmental protection and monitoring organization; technical training of environmental monitoring;

2. training method: combination of domestic training and training abroad
6. Conclusions and Countermeasures

6.1 Conclusions

6.1.1 Status Quo and Impact Forecast Of Various Environmental Elements

(1) Atmospheric environment

a) Current situation of atmospheric environment

By the current situation monitored in two sides of proposed Expressway Section, the atmospheric environment is good and within Class II quality standard except specific busy section of existing Fuzhou-Xiamen highway.

b) Forecast of atmospheric environment

After Expressway operating, in recent and medium period atmospheric environment quality will not go beyond Class III standard within 100 m and Class II out of 100 m; in forward period at the moment of little wind NOx will exceed Class II within 200 m and might surpass Class III within 100 m. The pollution at the interchange is more serious than that at road section, and NOx and CO both might go beyond the standard.

(2) Water environment

a) The present situation of water environment

The major rivers, which this Expressway involves, are Jinjiang river, Xiqi river, Jiuqi river, and Nanchu river. All the elements reach Class III quality standard for water except petroleum type. Because of the influence of upper reaches, water in Nanchu and Jiuqi rivers arrives at Class IV standard. Water at other sections agrees with Class I. The conclusions from the investigation about marine living things are the same as the above mentioned.

b) Forecast of water environment

At ordinary times the Expressway has very fewer impact on water environment. At the time of raining, surface runoff will influence the
near river section. However, in the meanwhile the water volume of river is much larger, so the concentration of polluted materials in river is distributed very little.

In Puli service area, the sewage's impact on Jiupi river in Nan'an is also within the specialized range provided the sewage has been disposed.

(3) Acoustic environment

a) Status quo of acoustic environment

Presently ambient noise along the route is at the range of 48-61 dB. The average sound level is 56 dB. On average, the sound level in the evening is 6-7 dB(A) lower than in the daytime and is 50 dB(A). Compared to the international criterias, the sound level is lower in the daytime and higher in the evening.

b) Forecast of acoustic environment

With the growth of vehicle flow, the sound level along the route will be raised and the influenced scope will be enlarged uninterruptedly. The sound level of twenty-six sensitive points along the way will exceed the standard 10 dB(A) in the evening. It's estimated that residents within the range of 30-50 m from the road will be effected severely. Thus they should be relocated or soundproof wall should be built for them. See the special report on noise for details.

(4) Vibration

The calculated values L10 for environmental vibration current situation are basically below 70 dB(A). After completion of highway, its affected scope is mainly within 30 m. Anti-vibration ditches may be dug for the area which should be protected particularly. For ordinary areas, it will reach the standard so long as some treatments to prevent the vibration have done to drainage gutter on each side of highway.

(5) Loss of water and erosion of soil
Now the water and soil are maintained better for the section of area along the route. Commonly the vegetation is better and most of sloping lands are treated as terrace. The district belongs to the slight area of soil erosion. The loss of water and erosion of soil will be caused during the Expressway construction. However, the extent of erosion has something to do with the protection measures at the time of digging. After earth-covering and afforesting are done to construction site while the completion of Expressway, the loss of water and erosion of soil will return to its former level.

6.1.2 Conclusions

(1) The Quanzhou-Xiamen Section is the busiest section of area in Fujian Province. The construction of Expressway is of momentous significance for economic development of Fujian province, especially for Xiamen, Quanzhou and Zhangzhou Delta district. Therefore, it's very essential to construct the Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway.

(2) Construction of Fuzhou-Xiamen Expressway has a certain impact on environment. However, since the Expressway absorbs a great number of vehicle flow of original Fuzhou-Xiamen highway so as to relieve the environmental pollution of existing Fuzhou-Xiamen highway area, and the emission volume from a single vehicle on Expressway is less than the present one, on the whole, the Expressway construction is advantageous to environment.

(3) The Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway should be far away from residential areas as possible to reduce the demolition and relocation during the route selection. The guiding principle of avoiding the environmental sensitive points is correct, the route alignment is reasonable.
(4) By the investigation on residents along the way, the masses support the construction of Expressway. So long as the relocation of the residents is done well, the Expressway will gain the supports from the broad masses of people.

(5) The route section of Xiahouzi in Ridge Xiaoyinling brings the masses strong reaction, and can make harmful effects on noise, vibration, atmosphere and sunlight. It's suggested that the route should be given thorough cooperation again to avoid the village.

(6) From the above assessment, it may be concluded that the construction of Quanzhou-Xiamen Section of Fuzhou-Xiamen Expressway is feasible on environment after the environmental protection measures have been realized according to the section mentioned above.

6.2 Countermeasures and Suggestions for the Environmental Protection

Countermeasures for the environmental protection have been set forth in above different sections. This section chooses its highlights to expound according to construction and operation periods.

6.2.1 Construction Period of Expressway

(1) The traffic of the existing highway, where the Expressway intersects the current Fuzhou-Xiamen highway and its chief branch roads, must be influenced while building the Expressway, especially at the sites of interchange construction as Chengzhou, Puli, Lanxiao, and Hou'an, for its present traffic is very busy. So at these sections of the area, the construction makeshift roads must be built in the meanwhile of Expressway construction to keep the existing highway smoothly. On the other hand, consideration should pay attention to concentrated construction to reduce the building period possibly and relieve the impacts on environment.

(2) Construction noise
The construction fields must be over 50 m away from residential areas. For the areas not to guarantee to do so, the construction should be stopped from 22 to 6 o'clock at night because noise caused by the bulldozer, roller or mixer 50 m away from the road still goes beyond 65 dB and influences rest of inhabitants nearby severely. Therefore the construction must come to a halt at night while the road section of working is less than 50 m from residential areas.

(3) Atmospheric pollution

Parts of pavements of the Expressway Section are paved with asphalt. Since the asphalt smoke and dust are very poisonous and will originate from the heating and boiling, the asphalt processing must be taken sealing plant mix method with dust-removed equipments. This kind of processing must be done at the site far away from the residential areas whose distance is not less than 1 km. then the asphalt is carried to the designated spots with no heating source lorry.

Due to the mixing of building materials at the road section of construction, the transport for earthwork and stone will cause clouds of dust flying up, especially while weather scorching at the construction site, the dust of earth will be easier to fly up. However, if the sprayers are used to spray at road section of construction, the dust-befalling amount will decrease 70% or so. Thus the sprayer should be allocated to work in a regular time while constructing at the spots near to the residential areas.

(4) Camp buildings

The construction of this Expressway Section needs many building personnel, amounting to 16.09 million man-days. So at the camp building there should set up the three-stage septic tank and the mess hall to food and drink concentrically. In order to transport rubbishes to
specialized spots periodically for covering up. The temporary hooping fields for garbage should be founded too.

The camp buildings should pay attention to epidemic prevention. The peasant workers must receive health examination and prophylactic inoculation before employment. The medical room must be set up at bigger, concentrative camps.

(5) Resident relocation

Resident relocation is the great event influencing people's life directly, and also is the most important matter concerned by our Party and People's government. After the construction of Expressway was ratified, relative authority must work out the executive scheme for resident relocation at once to give adequate compensation according to the relevant policy of our country, and solve the employment problems of concerned personnel. The compensation costs should be delivered to the relocated families in the entire sum.

6.2.2 Operation Period of Expressway

(1) The vehicle flow of the Expressway will rise year by year, therefore, the noise and atmospheric pollutions become more serious yearly. When the Expressway is being built, it's neither economic nor possible to construct all the protection measures. So the major sensitive points must be monitored every year, and steps as building acoustic wall and relocating residents must be taken to the areas which go beyond the standard. Those measures are essential to reduce the contradiction between the Expressway and residents along the route to protect the environment and develop the economy.

(2) With the help of government sectors, the two sides of the Expressway are intended to be isolation areas, and aren't permitted to build schools and residential areas. Crops in two sides of the way should
be changed into planting the economic kind to reduce the Pb pollution on persons.

(3) At the section of area which is less than 50 m away from the residential area, the trumpet should be forbidden to blow while the vehicle speed limited and the evenness of pavement kept.

(4) To strengthen the afforestation. See the concrete measures on Section 4.4.4.

Appendix:


2. "Supplementary Report to the Preliminary Feasibility Studies on the Quanzhou-Xiamen Expressway Section of Fuzhou-Xiamen Highway Project" edited by FPCPDI. (May, 1991)


4. "Supplementary Report to the Engineering Feasibility Studies on the Quanzhou-Xiamen Expressway Section of Fuzhou-Xiamen Highway Project" by FPCPDI. (May, 1992)

5. "Plan and Vertical Profile Map of the Quanzhou-Xiamen Expressway Section of Fuzhou-Xiamen Highway" by FPCPDI.


7. "The Climate Data of Quanzhou in Fujian Province" by Fujian Provincial Climate Bureau.

8. "The Climate Data of Tongs'an in Fujian Province" by Fujian
9. "The Climate Data of Nan'an in Fujian Province" by Fujian Provincial Climate Bureau.

10. "The Climate Data of Xiamen in Fujian Province" by Fujian Provincial Climate Bureau.


14. "Environmental Impact Report on the Kaifeng-Luoyang Expressway Section (new-built, half-width) of National Highway 310" by Henan Provincial Environmental Protection Science Research Institute. (June, 1989)