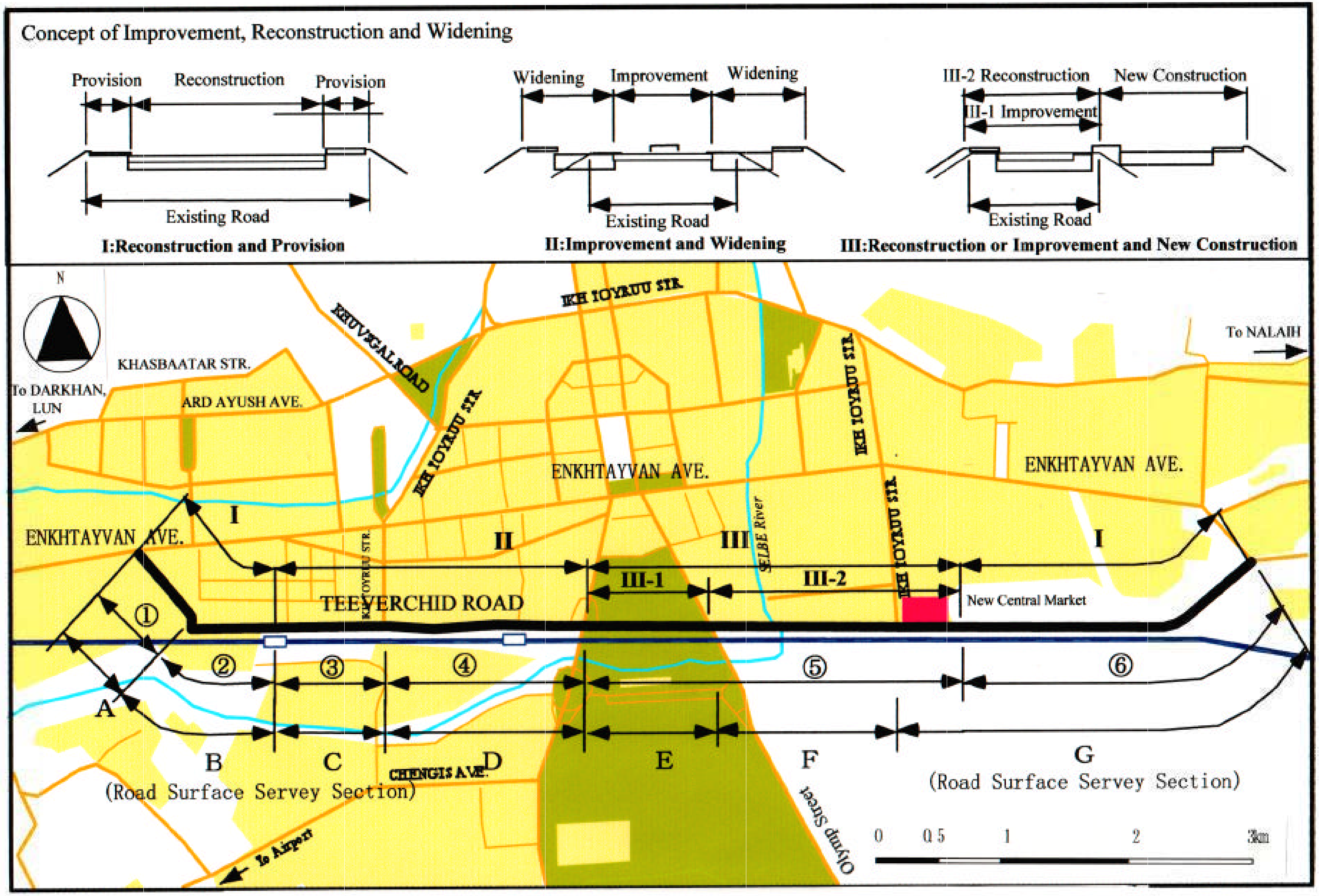


Fig. 2-3-16 Typical Cross Sections, Sections of Improvement and Road Condition Survey

ii) Vertical Alignment

- Vertical alignment will be planned to match existing road elevation in consideration with roadside.
- Vertical alignment will be set in consideration with disposal drainage.
- Vertical alignment on Selbe Bridge will be set in consideration with high water level, river horizontal alignment and Bridge Shape.

(2) Pavement

1) Design Procedure

Based on the results of road surface condition survey, the improvement of road is classified into two categories, namely overlay and reconstruction. New pavement structure is proposed for construction and reconstruction. The proposed pavement structure is examined for its practicality, considering number of heavy vehicles and available materials, and it is also checked for durabilities as per the standards prescribed by Manual for Asphalt Pavement, Japan.

2) Design of Pavement Thickness

The following pavement structure is proposed referring the performance and actual practices followed in Ulaanbaatar City. This pavement structure is assumed to have the $T_A$ value of 17 that represents the pavement thickness required if the entire depth of the pavement were to be constructed of hot asphalt mixture.

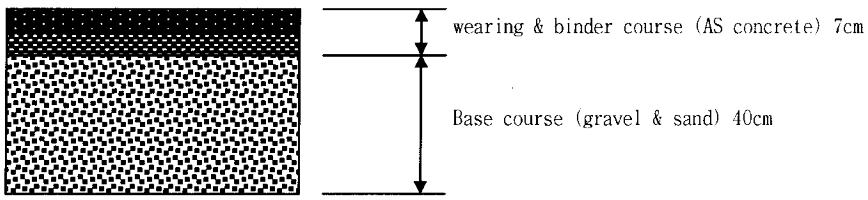



**Fig. 2-3-17 Actual Practice of New Pavement in UB City ($T_A$ = 17; H = 47 cm)**

Daily heavy traffic on Teeverchid Road varies from 450 vehicles to 1,000 vehicles in each direction, and the road classification by traffic volume is designated as B Class by Manual for Asphalt Pavement, Japan. Design CBR on subgrade is assumed 12 because embankment material used is weathered stone and gravel.

Road classification B and design CBR 12 require pavement structure more than $T_A$ = 17 and H = 35 cm and the minimum surface thicknesses of 10 cm.

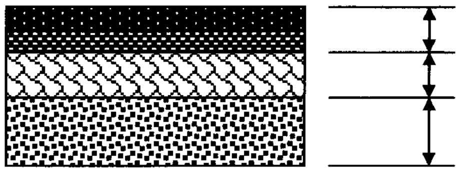



**Fig. 2-3-18 Proposed Pavement Structure ($T_A$ = 17.3; H = 35 cm)**

The minimum surface thicknesses of 10 cm may be justified by the following reasons;

i) The new pavement in UB City has smaller traffic, namely daily heavy traffic of 1,244 vehicles compared with 1,251 vehicles to 2,069 vehicles on Teeverchid Road.

ii) The minimum thicknesses is designated by Manual for Asphalt Pavement, Japan.

3) Construction Method

Based on the results of road surface condition survey, 3.2 km long existing pavement between Railway Central Station and Olymp Street is improved by overlay, scaring the existing surface and paving with a 10 cm thick wearing and binder course.

The existing pavement other than that section is improved by reconstruction, excavating 50 cm deeper than subgrade level and constructing new subgrade and pavement structure.

New pavement section including widening section is built by compacting embankment materials for roadbed, preparing subgrade more than design CBR 12 and integrating each pavement layer.

(3) Drainage

1) Rainfall Intensity for Road Drainage

The relevant authorities have not yet established the intensity curve for design of road drainage. Thus an intensity curve was formulated based on the short time rainfall data collected during site investigation (see Table 2-3-15).

**Table 2-3-15 Data of Rainfall in the Short Term Return Periods (Ulaanbaatar)**

| | 5 min | 10 min | 20 min | 40 min | Remarks |
|---|---|---|---|---|---|
| Rainfall (mm) | 6.4 | 10.0 | 12.8 | 15.3 | R24:52 |
| Rainfall Intensity (mm/hr) | 77.1 | 60.0 | 38.8 | 23.2 | 12-year |

Data source: Mongolia Meteorological Authority (1979 to 1998)

The frequency of short time rainfall is assumed at 12 years referring to the frequency of daily rainfall recorded during the same period. The Talbot type intensity equation was established by means of least square method as shown below.

$r = 1121/(t + 9)$
r: Rainfall intensity (mm/hr)
t: Concentration time (mm)

For the convenience in design of road drainage, rainfall intensities corresponding to the short term return periods are determined by using the ratio obtained from daily rainfall-frequency relation. Rainfall intensity for design of road drainage

**Table 2-3-16 Ratio from Daily Rainfall-Frequency Relation**

| Return Period | 12 year | 5 year | 3 year |
|---|---|---|---|
| Daily rainfall (mm) | 52 | 38 | 32 |
| Ratio | 1.0 | 0.7 | 0.6 |

**Table 2-3-17 Rainfall Intensity for Design**

| Concentration Time (min) | 12 year | 5 year | 3 year |
|---|---|---|---|
| 5 min | 80 | 56 | 48 |
| 10 min | 59 | 41 | 35 |
| 15 min | 47 | 33 | 28 |
| 20 min | 39 | 27 | 23 |
| 25 min | 33 | 23 | 20 |
| 30 min | 29 | 20 | 17 |

2) Road Surface Drainage

In developed area, drainage facilities will be installed to avoid damage of pavement by flood. In other area, drainage facilities will be uninstalled to facilitate roadside natural outflow.

Drainage system is planned along vertical alignment as disposals are limited to five locations.

Type of drainage structure is basically determined as U-ditch. But, pipe culvert is used in intersection and the reverse vertical alignment for drainage system.

Type of drainage structure and drainage system are as shown in Fig. 2-3-19.

3) Methodology

Rational Formula is used to calculate volume of rainfall outflow. Right-of-way areas are assumed as drainage area. Rainfall probability period of three years is adopted.

The cross sections of drainage facilities are determined in comparison with volume of rainfall outflow and disposal capacity.

4) South of New Central Market

There is small bridge at south of New Central Market. But, the bridge is old and lost its roles and functions. Therefore, the bridge is recommended for demolition and a new pipe culvert shall be installed in its place.

Rational Formula is used to calculate the volume of run off. Areas near the New Central Market is assumed as drainage area.

As a result, double pipe culvert (Dia. 1200) is selected as a design structure.

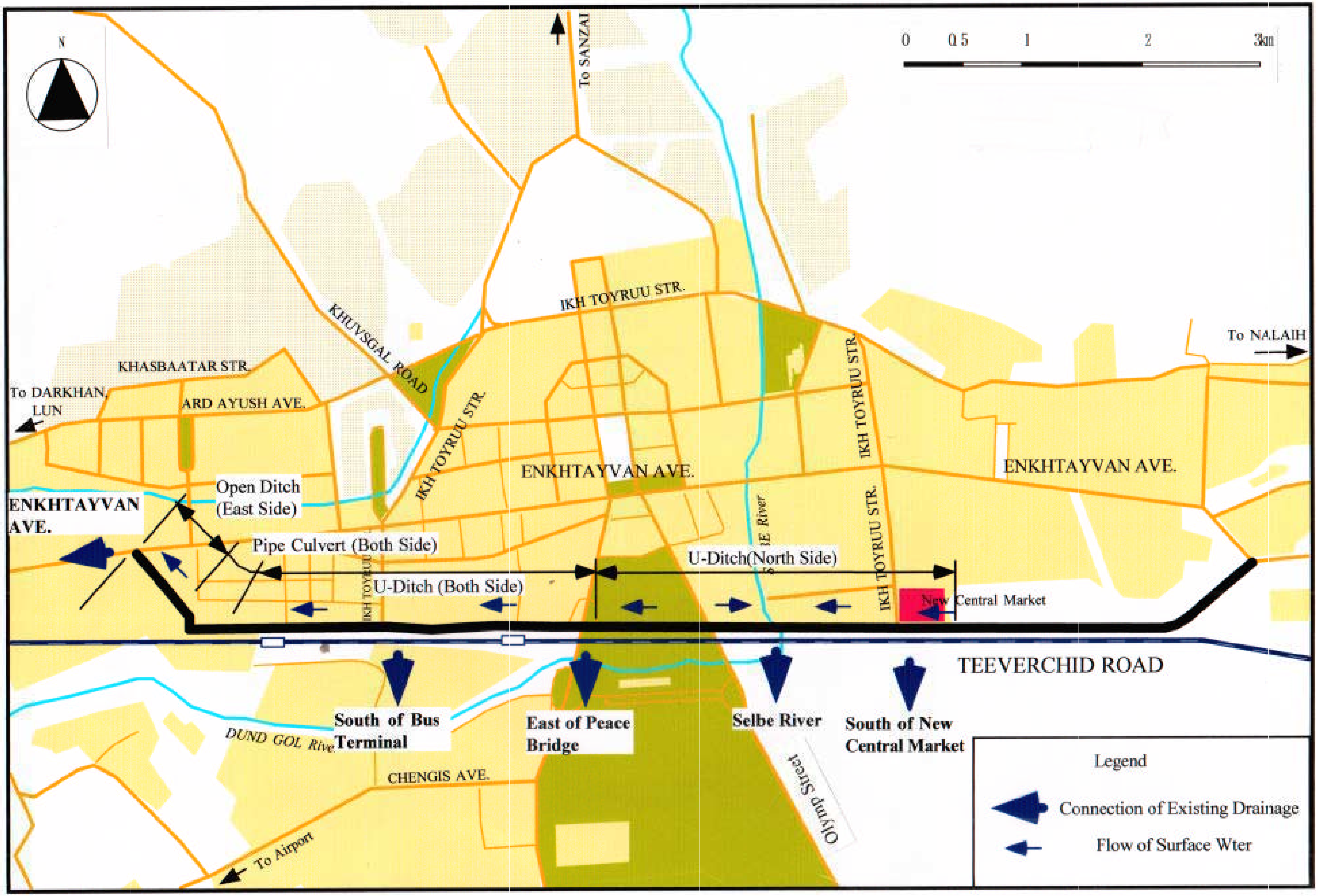



Fig. 2-3-19 Drainage Facilities and System

(4) Intersections and Street Lighting

Location of channelized intersection and street lighting are shown in Fig.2-3-20.

1) Channelized intersection

The road to be connected with Teeverchid Road are 2-lanes or more, and the intersections need traffic control. Therefore, the intersections will be channelized and installed traffic signal. Though, East End Intersection of Teeverchid Road will be planned to be roundabout, same as existing situation.

2) Street Lighting

From the viewpoint of the traffic accident prevention in the night, the lighting facilities will be installed on the intersection with the main arterial road and the sections where the important damage from the deviation to the roadside is anticipated.

And, the sections where the lighting facilities have been installed at present will be installed.

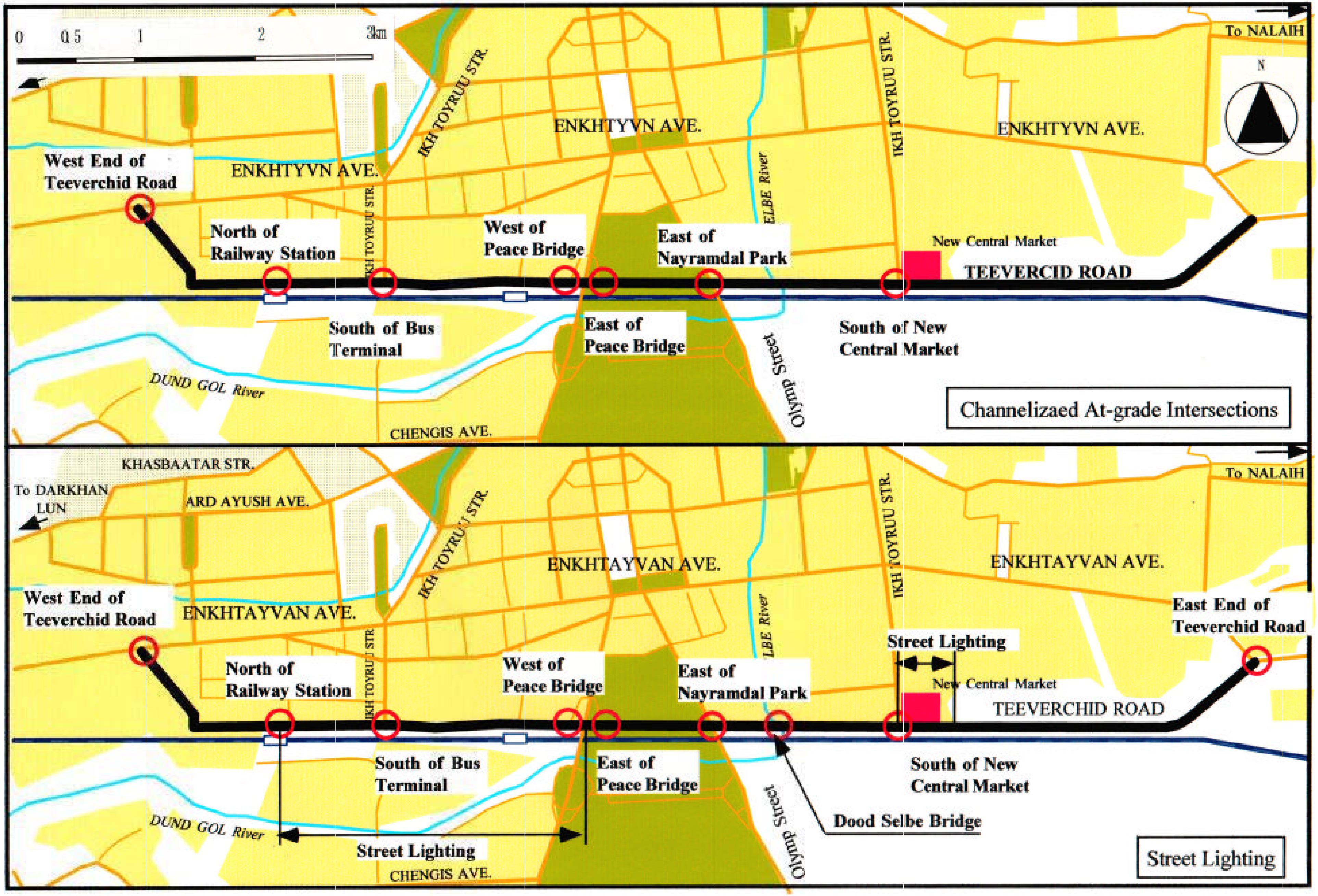



**Fig. 2-3-20 Location of Channelized A-grade Intersections and Street Lighting**

(5) Hydrological Analysis

1) Evaluation of Design Discharge for Selbe River

The dimension of proposed bridge on the Selbe River should be designed based on the master plan of river improvement. However the master plan has not been completed and no definitive plan is formulated. Some information confirmed at site, the scale of design discharge and discharge at Teeverchid Road are as follows:

- Flood protection scale: 100-year return period (based on ministry code)
- Design discharge: 420 $m^3/s$ at Teeverchid Roads (A = 290 $km^2$)

From the above conditions, the specific design discharge, q  is determined at 1.4 $m^3/s/km^2$.

Accordingly the design discharge at proposed bridge site (A = 296 $km^2$) is estimated at 412 $m^3/s$ by using the above specific discharge. An evaluation of the design discharge was carried out by applying Mononobe's approach and rational formula. The results show the appropriateness of design discharge (ref. Table 2-3-18).

**Table 2-3-18 Evaluation of Design Discharge at Teeverchid Roads**

| Flood Scale (yr) | Daily Rainfall (mm) | Area of Basin ($km^2$) | Length of River (km) | Concentration Time (hr) | Runoff Coefficient (f) | Rainfall Intensity (mm/hr) | Discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|
| 100 | 80 | 290 | 34 | 3.2 | 0.4 | 12.7 | 412 |

The runoff coefficient 'f' is evaluated as 0.4 by using the estimated discharge of 239 $m^3/s$ at pedestrian bridge 2 (ref. Table 2-3-12) and daily rainfall of 44.2 mm occurred during the 1982 flood.

Q = 1/36 x f x r x A (Rational Formula)
f = 3.6 x Q/(r x A) = 0.4

Where, the rainfall intensity (r) is determined by means of Mononobe Approach under the following conditions:

Flood velocity = 3.5 m/s, flood concentration time = 3.2 hr

$Tc = 0.5 + 34000/ (3.5 \times 3600) = 3.2$ hr
$R = R24/24 \times (24/Tc)^{0.667} = 12.7$ mm/hr

2) Basic Conditions of River Section

The data on design river section and implementation program for the proposed bridge were not available during the site investigation. Accordingly, the river section for bridge design was formulated referring to the present river conditions. The design conditions are as follows:

1. River cross section: average width 44 m, depth 2.2 m
2. River bed slope: 1 to 260
3. Design riverbed: EL 1289.5 m (almost same level as present riverbed)
4. Roughness coefficients of river: 0.03 (considering the concrete revetment)
5. Freeboad: 0.8 m (considering the scale of discharge of 420 $m^3/s$)

The river capacity of flow at bridge site is evaluated as about 300$m^3/s$, which corresponds to 15 years to 20 years of flood frequency (ref. to Table 2-3-19)

**Table 2-3-19 Rainfall, Discharge and Return Period**

| Return Period (year) | Rainfall (mm) | Discharge ($m^3/s$) |
|---|---|---|
| 100 | 80 | 420 |
| 50 | 75 | 390 |
| 20 | 63 | 330 |
| 10 | 47 | 250 |
| 5 | 38 | 200 |
| 2 | 28 | 150 |

(6) Bridge

1) Design River Section

The scale of the Selbe bridge shall be studied based on the existing river section ($Q = 300$ $m^3/s$) because the future river planning is not yet made. However, taking account of the future river section ($Q = 420$ $m^3/s$), the scale and alignment of bridge and approach road shall be determined based on the design river section as follows.

- Design River Bed Level: EL 1289.5 m
- High Water Level: EL 1291.7 m (Design River Bed Level+2.2m)
- Future Design Discharge: Q = 412 $m^3$/s (100-year return period)
- Design Discharge in this Project: Q = 300 $m^3$/s
  (15 to 20-year return period)
- Design Free Board: more than 0.8 m
- Design Road Surface: more than (HWL + Free board + Girder height)

The dimensions of existing and design river sections at Selbe bridge are shown in Table 2-3-20.

**Table 2-3-20 Dimensions of River Section**

| Item | Dood Selbe | Existing River Section | | Remarks |
|---|---|---|---|---|
| Existing Conditions | River Width | 45m | | |
| | Road Surface Level | EL 1293.1m | | |
| | Girder Bottom Level | EL 1292.1m | | |
| | Lowest River Bed Level | EL 1289.7m | | |
| | River Bed Width | 37.87m | | |
| | Girder Bottom-River Bed | 2.2m | | |
| | HighWater level | EL 1292.0m | | |
| | Water Level (May) | EL 1290.0m | | |
| | | Future River Section | Design River Section | |
| Proposed Dimension | Discharge (Q) | 420$m^3$/s | 300$m^3$/s | |
| | River Width(Bridge Length) | 64m (68.1m) | 48.6m (51.12m) | Cross (Skew70degree) |
| | HighWater level | EL 1291.7m | EL 1291.7m | |
| | River Bed Width | 55m (58.5m) | 39.6m (42.1m) | Cross (Skew70degree) |
| | River Bed Level | EL 1289.5m | EL 1289.5m | |
| | Embankment Hight | H=3m | H=3m | |
| | Free Board | 0.8m | 0.8m | |
| | Road Surface Level(Min) | El 1294.7max (m) | EL 1294.7max (m) | |

2) Design Standard

Following Japanese Standards were applied for design of Dood Selbe Bridge, as the result of discussion with Mongolia.

i) Applied Design Specification

- Road Geometric Standard: Japan Road Association
- Specifications for Highway Bridges: Japan Road Association
- Specifications for River Facilities: Japan River Association

ii) Design Standard for Bridge

As the result of discussion with Mongolia, typical cross section of Dood Selbe Bridge is shown in Table 2-3-21 and Fig. 2-3-21.

a) Typical Cross Section of the Bridge

**Table 2-3-21 Dimensions of Typical Cross Section**

| Item (for 2 lanes) | Dimensions | Remark |
|---|---|---|
| Carriage way | 2 × 3.25 = 6.5 m | |
| Shoulder (carriage way side) | 0.5 m | |
| Shoulder (walk side) | 2.0 m | |
| Sidewalk | 2.0 m | |
| Curb (rail) | 2 × 0.5 = 1.0 m | |
| Total width | 12.0 m | Total 24.0 m (4 lanes) |
| Cross fall | 2 % | |
| Pavement | Asphalt (7 cm) | |

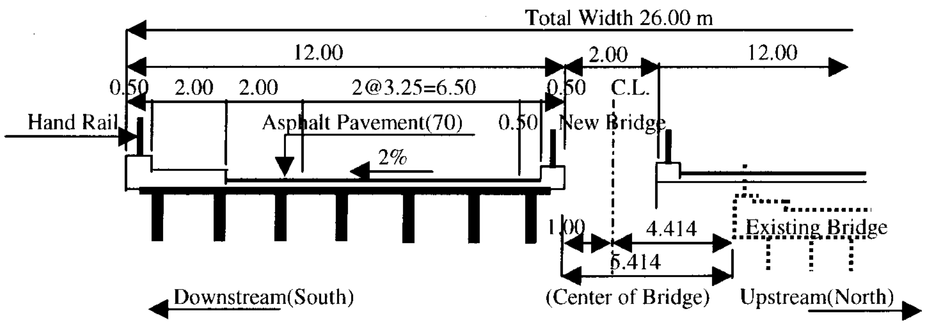



**Fig. 2-3-21 Typical Cross Section for Bridge**

b) Design Analysis

The structural analysis is based on the elastic theory. The framed structural system shall be applied to consider the distribution of load. The strength of the structural members shall be verified within allowable strength.

c) Design Load

The loading system for the structures shall be applied based on the Japanese Specifications for the following items.

- Dead Load

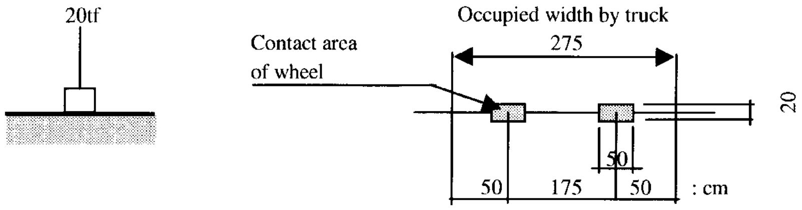
**Table 2-3-22 Unit Weights of Materials (kgf/m$^3$)**

| Material | Unit Weight | Material | Unit Weight |
|---|---|---|---|
| Steel, Cast steel, Forged steel | 7,850 | Asphalt | 2,300 |
| Cast iron | 7,250 | Bituminous material | 1,100 |
| Aluminum alloys | 2,800 | Embankment, Subgrade Soil (compacted) | 1,900 |
| Timber | 800 | Natural soil | 1,800 |
| Concrete | 2,350 | Ground water | 1,000 |
| Reinforced/Prestressed Concrete | 2,500 | Cement mortar | 2,150 |

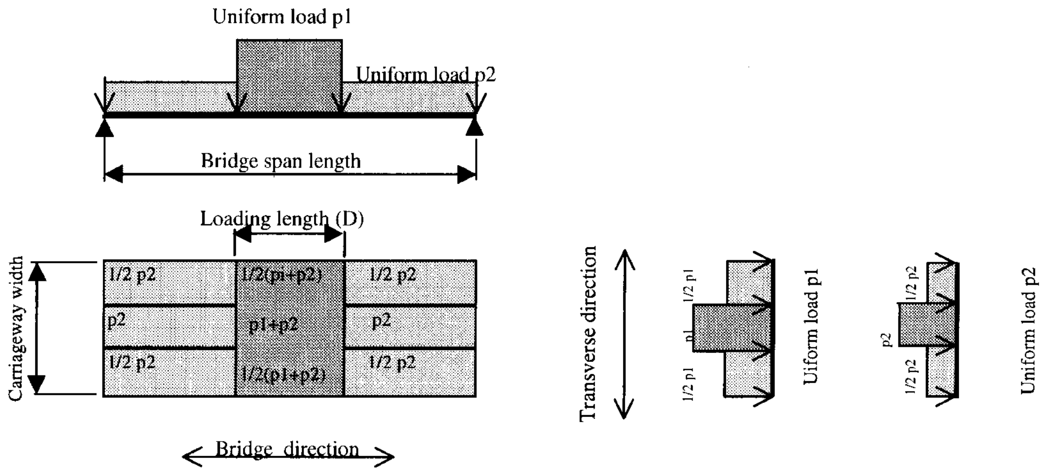
- Live Load and Impact

  - Live Load

    Live load system for the bridge design adopted the Japan standard (B live load : TL-25). Loading method of live load is shown in Fig. 3-3-9.




**T-Loading**




**L-Loading**

**L- Loading ( B-Live Load, Japan )**

(L: Span)

| Main loads ( width 5.5m ) | | | | | | Sub loads |
|---|---|---|---|---|---|---|
| Loding length D (m) | Uniform loads p1 Load (kgf/m$^2$) | | Uniform loads p2 Load (kgf/m$^2$) | | | (width-5.5m ) |
| | for Bending Moment | for Shearing Force | L<80 | 80<L<130 | L>130 | 50% of if |
| 10 | 1,000 | 1,200 | 350 | 430-L | 300 | Main load |

| | For Slab | For Main Girder | | |
|---|---|---|---|---|
| Span Length (m) | - | L≦80 | 80<L≦130 | 130<L |
| Uniform Load (kgf/m$^2$) | 500 | 350 | 430-L | 300 |

**Fig. 2-3-22 Loading System in Japan (B-Live Load, TL-25)**

- Impact Coefficient

  The impact load by live load is different by the superstructure type. Impact coefficient of Dood Selbe Bridge as concrete bridge was calculated to use following equation in Japanese standard.

  Reinforced Concrete    T-load  i = 20 / 50 + L
                         L-load  i = 7 / 20 + L
                         [I : Impact Coefficeient, L : Span Length (m)]

- Other Loads

  Other loads for design of superstructure and substructure are as follows.

  - Earth pressure: Calculation of earth pressure by the coulomb' earth pressure formula in normal stage and in seismic stage (substructure).
  - Hydraulic pressure: Calculation of load combination including static water pressure or running water pressure (substructure).
  - Buoyancy: Calculation of load combination including buoyancy or uplift pressure by lower water level (substructure).
  - Temperature change: Calculation of the throw of movable bearing (superstructure).
  - Seismic Force: Design seismic horizontal coefficient Kh = 0.10 (Superstructure and Substructure)

d) Strength of Materials

Strength of materials for concrete and steel of superstructure or substructure is as follows.

- Concrete:

  Specific Strength : 28 days

| | |
|---|---|
| RC Main Girder | $\sigma$ ck = 240 kgf/cm$^2$ |
| RC Deck Slab | $\sigma$ ck = 240 kgf/cm$^2$ |
| Cross Beam | $\sigma$ ck = 240 kgf/cm$^2$ |
| Curb, Block | $\sigma$ ck = 210 kgf/cm$^2$ |
| Abutment and Pier | $\sigma$ ck = 210 kgf/cm$^2$ |

- Reinforcing Bar

  Deformed Bar- SD 295 Yield Point Strength $\sigma$ py = 30 kgf/mm$^2$

3) Bridge Design

   i) Design Concept

   The design of bridge shall be conducted in accordance with the following basis.

   a) Scale of Bridge

   The scale of bridge is determined based on the hydrological study, future plan and present topographic conditions. In addition, to ensuring appropriate river section, the scale of bridge is planned to avoid the obstructions from river flow.

   The free board (80 cm) under the girder is appropriate to set up in terms of past flood and record.

   b) Type of Bridge

   Type of bridge is determined considering the river condition, construction skills and experiences, availability of machinery and materials, construction method, seasonal weather changes, construction cost and future maintenance in future.

   The appropriate shape and substructure type of bridge is planned in consideration of the results of topographical and geological survey.

   c) Economical Activation and Technology Transfer

   The construction system and method shall be planned to stimulate economic activation, technology transfer, and to apply the local technology and labors.

   As stated in the above design concept, the superstructure type of the bridge is designed with concrete material based on the construction experience, availability of materials and no maintenance aspects. The foundation of substructure is determined as spread footing type based on geological conditions. The shape and type of substructure are also selected from the view points of the scale of superstructure, economy and stability.

ii) Determination of Location and Scale of Bridge

The existing Selbe bridge is to be replaced because of lack of stability such as durability, function and structural aspects. Therefore, the new bridge, which is 4 lanes width, is designed at this location.

The location of bridge is to be determined according to the alignment, detour road and closed construction.

Furthermore, the location and scale of bridge shall also be planned considering topography, river morphology and ease in removing the existing bridge as shown in Fig. 2-3-23.

The skew angle of bridge is to be 70 degrees as mentioned before. The bridge length is same as existing river section and width. However, the bridge length calculated based on the discharge of 420 $m^3/s$ in future stage shall be considered to extend the beam toward to West.

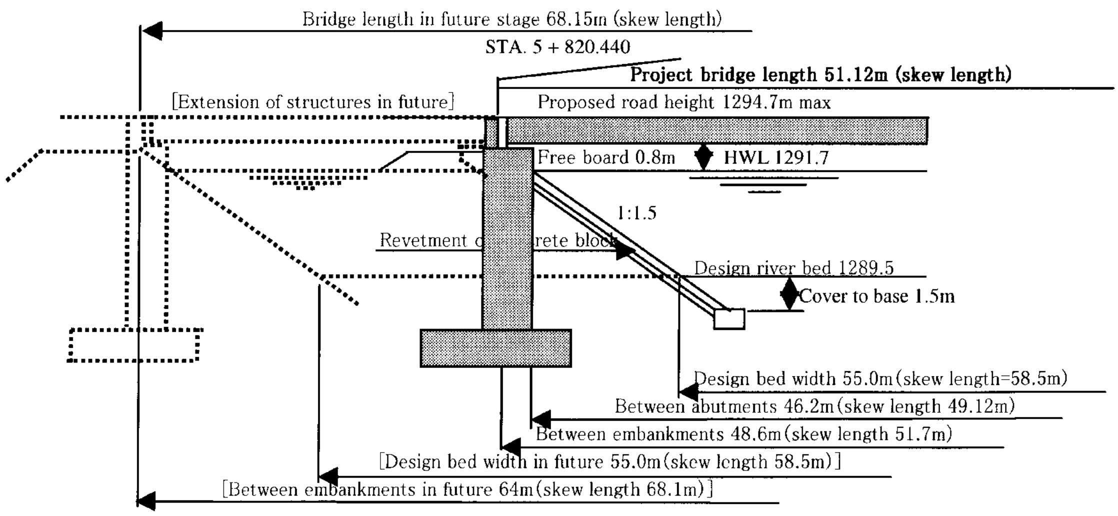



**Fig. 2-3-23 Relationship between Bridge Length and Design River Section**

The construction method of the Selbe bridge shall be planned as follows;

1st. Construction of South side new bridge using existing bridge traffic.
2nd. Traffic open on South side bridge, demolition of existing bridge.
3rd. Second construction of North side new bridge.

These concepts and construction sequence of bridge is shown below in Fig. 2-3-24.

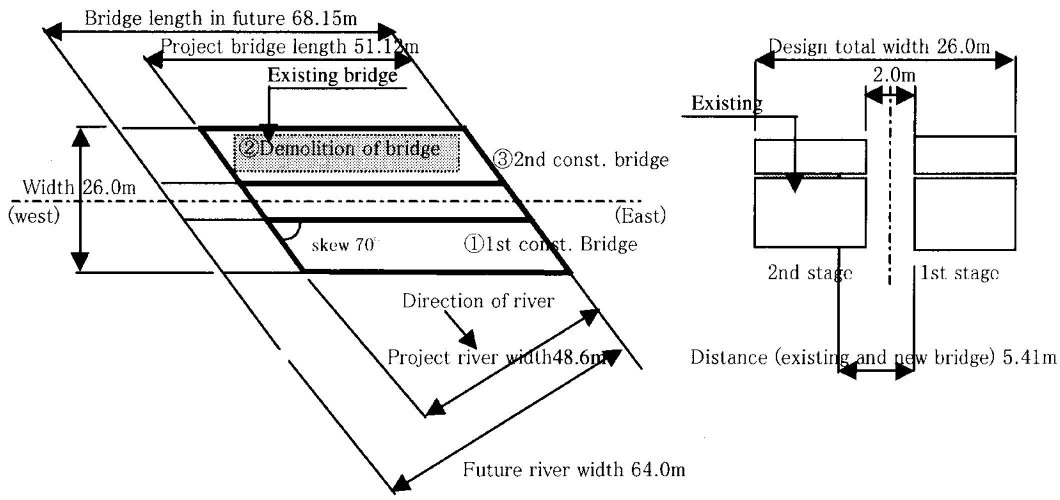



**Fig. 2-3-24 Construction Concept and Sequence for Selbe Bridge**

iii) Selection of Bridge Type

The types of the bridge are selected taking account of present conditions based on economical aspect, availability of materials, technical level, construction experience and method, easier construction and maintenance methods. Moreover, the substructure and foundation shall be determined considering the results of topographic and geological surveys.

The results of study for structural bridge type are as described below.

a) Applied Superstructure Type

The type of superstructure is classified into reinforced concrete (RC) bridge, prestressed concrete (PC) bridge and steel bridge.

The general relation of superstructure type and appropriate span length with the ratio of girder height and span length are shown in Table 2-3-23.