ENGINEERING AND CONSTRUCTION STANDARD

FOR

CULVERT BRIDGES

AND

RELATED STRUCTURES

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1. SCOPE

This Standard summarizes the information required for design and construction of culvert bridges with maximum span length of six meters, including related minor structures.

In preparation of this Standard the appendix to technical instruction No. 11 of Ministry of Road and Transportation have been utilized. This Standard is intended to serve as guide for preparation of specifications and for reference by engineers of Oil Industries and its Consultants. In considering this Standard, however the Engineer should bear in mind that it was developed for more or less typical conditions. If span length exceeds 6 meters or the structure is unusual in some other respects, the engineer should use his best engineering judgment in selection of proper criteria and treat it as an independent project.

2. REFERENCES

In this Standard the following standards have been referred to and to the extent specified form a part of this Standard:

PBO (PLAN AND BUDGET ORGANIZATION)

Publication No. 83 "Culvert Bridge Typical Standard Drawings"

MINISTRY OF ROAD AND TRANSPORTATION

"Appendix to Technical Instruction No. 11"

AASHTO (AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS)

"Standard Specification for Highway Bridges", (1977)

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

4. DESIGN

4.1 General Features of Design

Culvert bridges should be engineered for the specific site and conditions. Design and Construction should not be attempted without experienced supervision. Recommendation concerning culvert bridge design should be in accordance with Standard Drawing No. IPS-D-CE-170 sheet 1 through 11.

4.2 Culvert Bridge Location

Selecting favorable stream crossings should be considered in preliminary route determination to minimize construction, maintenance and replacement costs.

In design of culvert bridges, the designer should make sure that the structure is adequate to pass flow of water without causing harmful flooding on the upstream sides or scour and erosion where flow is concentrated. The flow of the stream should not be restricted. Location should be selected in a manner that fulfills the fundamental requirement of getting water across and away from the road as soon as possible with uniform velocity of flow through the culverts in order to minimize scour or silting up of the waterway.

Sharp changes of direction in the flow of water are undesirable, as they produce debris jams as well as tend to clog the culvert with soil deposits. If road is crossing the stream at right angle, the culvert's structure should be designed at right angle to center line of the road:

4.3 Culvert Bridge Waterways

The determination of adequate waterway opening for stream crossings is essential to design safe and economical culvert bridges. Hydraulic studies of bridge sites are necessary.

Part of preliminary design of a bridge and reports of such studies should include applicable parts of the following outline:

4.3.1 Site data

1) maps, stream cross-sections;

2) complete data on existing bridges, or culverts including dates of construction and performance during past flood;

3) available high-water-marks with dates of occurrence;

4) information on debris and channel stability;

5) factors affecting water stages, such as high water from other streams, reservoirs and flood control projects.

4.3.2 Hydrologic analysis

Velocities at site, for flood discharges to be considered in design of structure, should be determined.

4.3.3 Hydraulic analysis

1) Compute back water and mean velocities at culvert bridge opening for various trial culvert bridge lengths and selected discharges.

2) Estimate scour depth at piers and abutments of proposed structures.

4.3.4 Waterway openings

For small structures having waterway opening not greater than 37.00 m² the area of opening required may be determined by use of Talbot formula or Burkliziegler formula. Having determined value of discharge (Q) from Burkliziegler formula, the area of opening shall be determined from Manning's formula.

4.4 Pier Spacing and Orientation

Piers shall be located to give a minimum interference to flood flow. In general, piers should be placed parallel with direction of stream current at flood stage. Adequate provision should be made for drift by increasing span length and vertical clearances.

4.5 Grade of Culvert Bridge Invert

Silting up of the culvert due to abrupt changes in the velocity of flow should be prevented. For this reason culverts are normally given the same slope as the stream bed.

4.6 Loads

Culvert bridge structures shall be proportioned for load in accordance with Appendix to Technical Introduction No. 11, "Loading Regulation on Road Bridges and Design Requirements"; of Ministry of Road and Transportation for:

1) Normal wheel load

Any point of the roadway may be loaded with a wheel load of 9 metric tones with additional 30% impact.

2) Normal truck load

The following truck load is to be considered:

4 wheels of 9 tons each =	36 tons (on bogie)
2 wheels of 4.5 tons each =	9 tons (on front axle)
Total	45 tons

4.7 Superelevation

The superelevation of floor surface of a culvert bridge on horizontal curve shall be provided.

4.8 Type of Structure

In selection of the type of structure, the designer should consider:

a) ease of construction;
b) future widening;
c) depth of floor system;
d) foundation status.

4.9 Protection from Scour

Where the natural stream velocity is high or where it is necessary to restrict the culvert bridge opening with a resultant high velocity which would cause bank scour, rip rap or other protection should be provided.

4.10 Handrail

Handrail shall be provided for culvert bridges in all industrial areas.

5. CONSTRUCTION

5.1 Excavation and Fill

5.1.1 General

Foundation excavation shall include the removal of all material, of whatever nature, necessary for construction of foundations and substructures in accordance with drawings or as directed by the AR*. It shall include the furnishing of all necessary equipment which may be required for the execution of the works. It shall also include the disposing of excavated material, which is not required for backfill, in a manner and in location so as not to affect the carrying capacity of the channel.

*** AR = Authorized Representative of the Owner.**

All substructures, where practicable, shall be constructed in open excavation and, where necessary, the excavation shall be shored, braced or protected by cofferdams in accordance with approved methods (refer to IPS-C-CE-112). When footing can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted with the approval of the AR and the entire excavation filled with concrete to the required elevation at the top of the footing.

5.1.2 Preservation of channel

Unless otherwise specified by AR no excavation shall be made other than for foundation. Location of natural stream bed adjacent to the structure shall not be disturbed without written permission of the AR.

5.1.3 Preparation of foundations for footings

All rock or other hard foundation material shall be freed from any loose material, cleaned and cut to firm surface, either level, stepped, or roughened as may be directed by the AR. All seams shall be cleaned out and filled with concrete, mortar or grout.

5.1.4 Cofferdams and cribs

a) General

Cofferdams and cribs for foundation construction shall be carried to adequate depth and heights as described in IPS-C-CE-112 and IPS-E-CE-130.

b) Protection of concrete

Cofferdams and cribs shall be constructed so as to protect fresh concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such-a-way as to extent into the substructure masonry without written permission from the AR.

c) Drawings Required

For substructure work, the contractor shall submit construction drawings showing his proposed method of cofferdam construction. Such drawings shall be approved by the AR before construction is started.

d) Removal

Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed after the completion of substructure.

e) Pumping

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping will be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it be done from a suitable sump separated from concrete works by a watertight wall or other effective means. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

5.1.5 Backfill

All material used for backfill shall be of a quality acceptable to the AR and shall be free from large or frozen lumps, wood or other extraneous material.

All spaces excavated and not occupied by abutments' piers shall be refilled with earth up to the surface of the surrounding ground, with a sufficient allowance for settlement. All backfill shall be thoroughly compacted and, in general, its top surface shall be neatly graded.

The fill behind abutment of all culvert bridges shall be deposited in well compacted, horizontal layers not to exceed 300 mm in thickness and shall be deposited on both sides to approximately the same elevation; at the same time adequate provision shall be made for the thorough drainage of all backfilling. No backfill shall be placed against any masonry culvert bridge abutment without written permission of AR and preferably not until the masonry has been in place for 14 days.

5.2 Concrete Structure

This work shall consist of furnishing, placing, finishing and curing concrete in culvert bridges and related structures in accordance with stipulations of AASHTO's "Standard Specification for Highway Bridges" (1977), Section 4 "Concrete structure", and in conformity with the related standard drawings", and IPS-C-CE-210 "Construction Standard for Concrete Structures".

5.3 Reinforcing Steel

This work consists of furnishing and placing reinforcing steel in accordance with AASHTO's "Standard Specification for Highway Bridges" (1977), Section 5 "Reinforcing Steel", and in conformity with standard drawings and IPS-C-CE-210.

5.4 Protection of Embankment and Slopes

This work consists of furnishing and placing a protective covering of erosion resistant material (rip rap), as slope or pier foundation protection in accordance with stipulation of AASHTO's "Standard specification for Highway Bridges" (1977), Section 15 "Protection of Embankments and Slopes", and in conformity with IPS-E-CE-140.

5.5 Waterproofing

When specified on the drawings, surfaces shall be waterproofed in accordance with AASHTO's "Standard Specification for Highway Bridges" (1977), Section 17 "Waterproofing".

5.6 Wearing Surfaces

Separate wearing surfaces, when required, shall conform to details shown on the drawings IPS-D-CE-170 sheet 1 through 11.

Careful and competent workmen shall be employed in preparing and placing the wearing surface. The wearing surface preferably shall be placed in two courses to assure a smooth riding surface. The AR shall specify or approve the method of cleaning and preparing the deck, applying the prime and tack coats, grading the aggregate, measuring the proportions, mixing the ingredients, regulating the temperatures, placing and compacting the material and selecting suitable atmospheric conditions for the works.

Prior to placement, the surface of the deck shall be thoroughly cleaned to ensure complete removal of all mill scale, dirt, debris, oil, grease, salt, and moisture. Air, water vapor, and other gases shall not be entrapped in or under the wearing surface.

5.7 Mortar Rubble Masonry

Where specified on drawings, construction of abutment, piers and protection walls with mortar rubble masonry should be in accordance with AASHTO's "Standard Specifications for Highway Bridges" (1977), Section 7 "Mortar Rubble Masonry".

6. INSPECTION

6.1 General

In the proper maintenance of culvert bridges annual field inspection should be done regularly and in the cases of floods, fires or other emergencies, immediate inspection should be carried out.

In the inspection of any culvert bridge it should be determined whether the waterway is blocked or partially blocked by drift, sediment, or other foreign material and whether there are indications that the water is bypassing the structure. The horizontal and vertical location of the inlet and outlet of the structure should be studied to determine the correctness of culvert flow line and if incorrectly located, the probable results. The waterway adjacent to and above and below the structure should be inspected for indications of scouring, filling, or change in channel that would affect the structure. During inspection, the adequacy of culvert opening to carry the run-off from the drainage area should be determined. This can be done by observing high-water marks, if available, or by talking with local people.

If a rainy season prevails at a certain time of the year in the geographic area in which the culvert bridge is located, it is advisable to make the annual inspection at a time when the corrections can be made before the rainy season starts. Emergency inspection should be made immediately following floods to determine damage and to remove drift.

6.2 Reinforced-Concrete Culverts

At all annual inspections they should be viewed closely for cracks which are indications of stresses that may result in the failure of the structure. Any signs of faulty concrete should be noted.

In the inspection of pipe culverts the alignment should be noted for settlement or lateral displacement. The minimum fill over the pipe should be determined. It is good practice to have at least 300 mm of fill over pipe culverts. The pipe should be inspected for cracks, breakage and stream erosion. The opening should be checked for accumulation of debris or sediment.