Reinforced Concrete Box Culvert Design

Extension of existing RCB's or increase in overfills over existing RCB's must be given careful consideration. The assumptions made on RCB designs prior to 1977 have been modified, based on Caltrans culvert research program. All existing RCB's should be checked by our new design criteria, if extended or if loads are increased. Prior to 1977, the previous designs considered only a 30% side pressure. Caltrans' culvert research has resulted in the application of load factor design and the establishment of two design conditions of loading for reinforced concrete box culvert design, i.e., 140V:42H, 140V:140H.

In most cases, with smaller sized RCB's and overfills less than 10 or 20 feet, the existing RCB's are structurally adequate. The fact that RCB's were based on service load design prior to 1977, also has, in some cases, provided a reserve design capacity. The introduction of P-13 loadings had a negligible effect on the evaluation of existing RCB's. The side wall capacity in larger size RCB's is usually the weakest "link" of existing RCB's under current loadings and needs special attention.

The introduction of changed loading conditions, such as a superimposed sound wall, has required removal and replacement of an existing RCB in one case, and encasement of the existing RCB in other cases.

A design review should be made by the Division of Structures when an extension, or increased loading, over an existing RCB culvert is proposed. The age, strength, and physical condition of the existing culvert should be considered. In addition, some existing RCB's may be designed only for an H15 load. "As-Built" drawings may be available from Headquarters (1120 N Street). If "As-Built" plans are not available, but the year of the design or construction is known, previous standard plans can be referenced (located in the Underground Structures Unit). If none of the above are available, core samples or other means of determining strength may be necessary. Additional soils data should be provided on all RCB extensions.

An analysis of the existing RCB should be made using the current RCB program, to assure that there is no overstress. Follow procedures in Chapter 6, Underground Structures, Bridge Design Practice; and design criteria in Bridge Design Specifications, Section 6 – Culverts, and Section 17 – Concrete Culverts.

Procedure:

1. Check the condition and strength of the existing RCB.
2. Review the As-Built or previous standard plans, if available, to determine original design method, loadings, and design material strengths. If unavailable, core samples may be taken.

Supersedes Memo to Designer 23-1 dated April 1988

3. Provide log of test borings where required. [See HDM 829.2(1)].
4. Check the allowable capacity of the existing culvert using current Caltrans design criteria.
5. Design the extension using current design standards D80, D81, and D82 – or provide a special design using present criteria. Note that the Standard D82 sheet provides some special RCB extension details.

Design Policy

For existing RCB's being extended, but where there is no additional load to be added, the minimum factors of safety shall be:

Roof and invert	1.5
Walls	1.0

If the above factors are met or exceeded and the box is in good condition with no signs of distress (cracking), retrofitting will not be necessary.

The factor of safety may be determined by adjusting the load factors in the RCB program and comparing the area of steel required to that provided. If the factor of safety is less than minimum, the subject member must be retrofitted.

For existing RCB's where there is additional load being added, the box must meet present design criteria or be retrofitted.

Jerry A. McKee

Jerry A. McKee

Floyd L. Mellon

Floyd L. Mellon

LFG:dm

23-1 REINFORCED CONCRETE BOX CULVERT DESIGN

Extension of existing reinforced concrete boxes (RCB's) or increase in overfills over existing RCB's must be given careful consideration. The assumptions made on RCB designs prior to 1977 have been modified, based on Caltrans culvert research program. Prior to 1977, the previous designs considered only a 30% side pressure. Caltrans culvert research had resulted in the application of load factor design and the establishment of two design conditions of loading for reinforced concrete box design, i.e., 22.0 kPa/m V : 22.0 kPa/m H, 22.0 kPa/m V : 6.6 kPa/m H. A recent review of RCB design parameters resulted in a change in design loadings and allowable shear in the concrete. The two design conditions of loading are now 22.0 kPa/m V : 15.7 kPa/m H, 22.0 kPa/m V : 5.5 kPa/m H. The allowable shear in the concrete has been reduced from $3.5\sqrt{f'c}$ to $3.0\sqrt{f'c}$. The standard plans for reinforced concrete boxes may be used until they are updated. Special designs should incorporate the latest design parameters.

Existing RCB's which will have additional load placed on them should be checked for structural adequacy. These box culverts should meet present design standards. If the RCB will have no additional load placed on it and it shows no apparent signs of structural distress, it will not require a structural analysis. All extensions will be designed to present design standards.

RCB's, based on service load design prior to 1977, have, in some cases, provided a reserve design capacity. The introduction of P-13 loadings had a negligible effect on the evaluation of existing RCB's. The side wall capacity in larger size RCB's is usually the weakest "link" of existing RCB's under current loadings and needs special attention.

A design review should be made when an increased loading is proposed over an existing RCB culvert. For unusual structures, the Underground Structures Technical Specialist should be consulted. The age, strength, and physical condition of the existing culvert should be considered. In addition, some existing RCB's may have been designed only for an H15 load. "As-Built" drawings may be available from Headquarters (1120 N Street). If "As-Built" plans are not available, but the year of the design or construction is known, previous standard plans can be referenced (located in the Underground Structures Unit). If none of the above are available, core samples or other means of determining strength may be necessary.

Supersedes Memo to Designers 23-1 (Metric version) dated June 1996.

An analysis of the existing RCB should be made following procedures in Chapter 6, Underground Structures, *Bridge Design Practice*; and design criteria in *Bridge Design Specifications*, Section 6 – Culverts, and Section 17 – Concrete Culverts.

Richard D. Land
Bridge Design Branch A Chief

Shannon H. Post
Bridge Design Branch B Chief

Michael A. Barbour
Bridge Design Branch C Chief

PC:jlw