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600 Major Rehabilitation Design

600.1 Introduction

Major rehabilitations are performed when the pavement condition is such that minor rehabilitation is no longer feasible or when geometric or capacity improvements require major work. Sometimes minor rehabilitation projects need to be elevated to major rehabilitation because of specific project conditions. For example, project level analysis may reveal excessive repair quantities that make minor rehabilitation a poor choice economically. However, funding is not always available to elevate a project to major rehabilitation.

The design period for major rehabilitations is established in Section 100. Most major rehabilitations require a life-cycle cost analysis using the procedures in Section 700 and a pavement selection according to Section 100. Major rehabilitations include the techniques given here, as well as complete removal of the existing pavement and replacement with either concrete or asphalt. The design of new concrete and asphalt is given in Sections 300 and 400 respectively.

600.2 Subgrade Determination

To design all major rehabilitations, including complete replacement, it is necessary to know the strength of the subgrade under the existing pavement. Prior to requesting pavement design for a major rehabilitation, soil borings should be taken and analyzed according to guidance from the Office of Geotechnical Engineering. If necessary for a preliminary design, subgrade strength can be estimated from historical subsurface investigations or by using the W(60) sensor readings from the FWD. The processed FWD data provides the subgrade design modulus for each direction tested.

601 Unbonded Concrete Overlay

An unbonded concrete overlay is a new concrete pavement placed on top of an old, deteriorated concrete pavement with a thin layer of asphalt in between to act as a bond-breaker. The thickness of an unbonded concrete overlay is derived from the required thickness for a new concrete pavement reduced by an amount based on the effective thickness of the existing concrete.

The design of an unbonded concrete overlay begins with the design of a new rigid pavement according to the procedures in Section 300. Next an asphalt overlay is designed using deflection analysis described in Section 500. The equation for determining the thickness of an unbonded concrete overlay, developed by the U.S. Army Corps of Engineers, is given below:

$$T_{UCO} = \sqrt{(T_N)^2 - (T_E)^2}$$

where:

T_{UCO}	=	Required thickness of the unbonded concrete overlay.
T_N	=	Required thickness for a new concrete pavement.
T_E	=	Effective thickness of the existing concrete.

The effective thickness of the existing concrete comes from the analyzed FWD measurements and a manual average of the effective thickness of the existing concrete, Deff (PCC). Best practice dictates averaging all the readings for the entire project, both directions, rather than averaging each direction separately and using the smaller or larger number. The design period used in deflection analysis does not matter as the Deff (PCC) does not change with different traffic inputs. The effective thickness of the existing concrete can also be estimated using the AASHTO '93 procedure when FWD measurements are not available. An example of an unbonded concrete overlay design is given in Figure 601-1.

To minimize the elevation increase of an unbonded concrete overlay, removal of any existing asphalt overlay prior to placing the bondbreaker is recommended. Deteriorated joints and cracks do not need to be repaired prior to the overlay. New concrete pavement should be placed wherever pavement must be removed to meet the elevation of mainline bridges or to provide clearance at overhead bridges. The thickness required for the new pavement is the thickness calculated for new pavement when designing the unbonded concrete overlay, T_N. A base of at least 6 inches (150 mm) of Item 304 should be placed under the new concrete.

Item 452 Non-Reinforced Concrete Pavement is recommended for all unbonded concrete overlays and the replacement areas. Because of the dowels and the required concrete cover, the minimum thickness is 8 inches (200 mm).

The bondbreaker layer should consist of 1 inch to 1.5 inches (25 - 38 mm) of Item 442 Asphalt Concrete Intermediate Course, 9.5mm, Type A (448), As Per Plan. Include a note in the plans instructing the contractor to use a PG64-22 binder, design the mix at 2% air voids, and use an N_{DES} of 50 gyrations. The bondbreaker **should not** be tacked down unless it will be used for maintenance of traffic operations.

602 Fractured Slab Techniques

Fractured slab techniques are a method of rehabilitating rigid or composite pavements. They involve impacting the concrete to break it into smaller pieces. The intent being to retard or eliminate reflective cracking in a new asphalt overlay. Fractured slab techniques involve placement of a thick asphalt overlay. The increased elevation due to the thick overlay requires full-depth replacement to meet mainline bridges and possibly to provide clearance at overhead bridges. The pavement in these replacement areas should be designed as full-depth flexible pavement on an aggregate base.

The design of fractured slab techniques begins with the design of a new flexible pavement as described in Section 400. The structural number required for the new flexible pavement is the basis for all the fractured slab designs.

Because these techniques turn a rigid pavement into a flexible pavement, subgrade conditions take on increased importance. Weak or wet subgrade can hamper the fracturing operation and may make the seating or rolling operation ineffective. Prior to designing a fractured slab technique, the W(60) sensor readings from the FWD should be carefully reviewed to try and determine local areas of soft subgrade that may require undercutting and replacement. Prior to constructing a fractured slab technique, soil borings should be taken and specific replacement and undercut quantities should be set up in the plans.

A fractured slab technique called break and seat was used extensively in Ohio in the past. While some sections had good performance, others performed very poorly. Break and seat is not approved for use as a major rehabilitation strategy.

602.1 Crack & Seat

Crack and seat is for use on non-reinforced concrete pavements only. It is not for use on reinforced pavements whether jointed or continuous. The cracks induced are very light and are visible only with the application of water. Prior to cracking, any asphalt overlay must be removed.

To design a crack and seat, the thickness of the cracked concrete is multiplied by a structural coefficient, given in Figure 401-1. Asphalt layers are then added until the total structural number is equal to or greater than the structural number required for a new flexible pavement. Any existing subbase under the concrete is neglected. An example is shown in Figure 602-1.

602.2 Rubblize & Roll

Rubblize and roll can be used on all concrete pavements although it is primarily intended for reinforced concrete. The rubblizing process does just what the name implies; it reduces the concrete to rubble. All slab action is destroyed and the concrete is transformed into an aggregate base. Prior to rubblizing, any asphalt overlay must be removed.

Subgrade support is even more important for rubblize and roll than for crack and seat. The Office of Geotechnical Engineering has established conditions when rubblizing is not allowed (see Geotechnical Bulletin 1: Plan Subgrades). Soil borings are strongly encouraged as early as possible in the design phase. Where subgrade conditions are very poor, analysis of the soil borings may reveal such large areas requiring replacement and undercutting that the decision to rubblize should be reconsidered. As a rule of thumb, areas three percent or more above optimum water content will require undercutting and replacement. Another rule of thumb was developed to estimate optimum water content: the optimum water content is the Plastic Limit minus four. Plastic Limit is not to be confused with the Plasticity Index. The Plastic Limit is equal to the Liquid Limit minus the Plasticity Index.

To design a rubblize and roll, the thickness of the rubblized concrete is multiplied by a structural coefficient, given in Figure 401-1. Asphalt layers are then added until the total structural number is equal to or greater than the structural number required for a new flexible pavement. Any existing subbase under the concrete is neglected. An example is shown in Figure 602-1.

603 Whitetopping

Terminology regarding whitetopping is not universally consistent. The whitetopping referred to here is the construction of a conventional new rigid pavement on top of an old asphalt pavement. It is not to be confused with any type if thin or ultra-thin whitetopping which is a thin layer of concrete bonded to an old asphalt surface to prevent rutting and shoving.

Whitetopping is designed as a new rigid pavement using the existing asphalt pavement as the base for determining the modulus of subgrade reaction. The requirements of Section 500 apply, including the minimum thickness.

604 Shoulder Use for Maintenance of Traffic

When major rehabilitation requires the use of old shoulders for maintenance of traffic operations during construction, the structural integrity of the shoulders should be verified. Verification may include pavement history, coring, non-destructive testing, empirical calculations etc., to determine the feasibility of use. Shorter duration maintenance of traffic operations may not require as detailed an investigation. Shoulders originally built thinner than the driving lanes that have never been rebuilt, even if they have been overlaid, can almost never be used for maintenance of traffic regardless of duration.

604.1 Pavement for Maintaining Traffic

When the shoulders are deemed structurally inadequate for maintenance of traffic operations during construction they may require replacement. The replacement pavement is typically constructed in accordance with Item 615 Roads and Pavements for Maintaining Traffic.

Longer duration maintenance of traffic operations may warrant a new pavement design of either concrete or asphalt given in Sections 300 and 400, respectively. Critical, high volume locations, such as interstate cross-overs where failure could shut down the entire road, should always be checked for a new pavement design rather than relying on the buildups in Item 615. If the replacement pavement will be left in place, design calculations should be performed to confirm that the proper thicknesses and materials are specified.

List of Figures

Given:

- Rigid Pavement Design Example, Figure 302-1
- Existing pavement buildup: 3" Asphalt
9" Reinforced Concrete
6" Subbase
- Deflection Analysis, Average Deff = 8.69”

Problem:

Design an unbonded concrete overlay.

Solution:

Obtain required thickness for new rigid pavement.

T_N = 10" (from Figure 302-1)

Obtain effective thickness of existing concrete.

T_E = 8.7" (from deflection analysis)

Calculate required thickness of unbonded concrete overlay.

$$T_{UCO} = \sqrt{(10)^2 - (8.7)^2}$$
$$T_{UCO} = \sqrt{100 - 75.69}$$
$$T_{UCO} = \sqrt{24.31}$$
$$T_{UCO} = 4.9"$$

Minimum thickness of unbonded concrete overlay = 8"

Items of work:

452	8"	Non-Reinforced Concrete Pavement, Class QC1 with QC/QA
442	1”	Asphalt Concrete Intermediate Course, 9.5mm, Type A (448), As Per Plan
202		Wearing Course Removed

Include a plan note requiring PG64-22 binder, for the mix to be designed at 2% air voids, and an N_{DES} of 50 gyrations.

Crack & Seat Example

Given:

- Flexible Pavement Design Example, Figure 402-1
- Existing pavement buildup: 3" Asphalt
  9" Non-Reinforced Concrete
  6" Subbase

Problem:
Design a Crack & Seat project.

Solution:
Obtain required structural number for a new flexible pavement.
SN = 5.04 (from Figure 402-1)

Determine the required buildup using the structural coefficients given in Figure 401-1

Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (446)	1.5"	0.43	0.65
442 AC Intermediate Course, 19mm, Type A (446)	1.75"	0.43	0.75
301 Asphalt Concrete Base, PG64-22	3.5"	0.36	1.26
321 Cracked & Seated Concrete	9"	0.27	2.43
	Total Structural Number =		5.09

Rubblize & Roll Example

Given:

- Flexible Pavement Design Example, Figure 402-1.
- Existing pavement buildup: 4" Asphalt
  9" Reinforced Concrete
  6" Subbase

Problem:
Design a Rubblize & Roll project.

Solution:
Obtain required structural number for a new flexible pavement.
SN = 5.04 (from Figure 402-1)

Determine the required buildup using the structural coefficients given in Figure 401-1.

Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (446)	1.5"	0.43	0.65
442 AC Intermediate Course, 19mm, Type A (446)	2"	0.43	0.86
302 Asphalt Concrete Base, PG64-22	6.5"	0.36	2.34
320 Rubblized Concrete	9"	0.14	1.26
	Total Structural Number =		5.11