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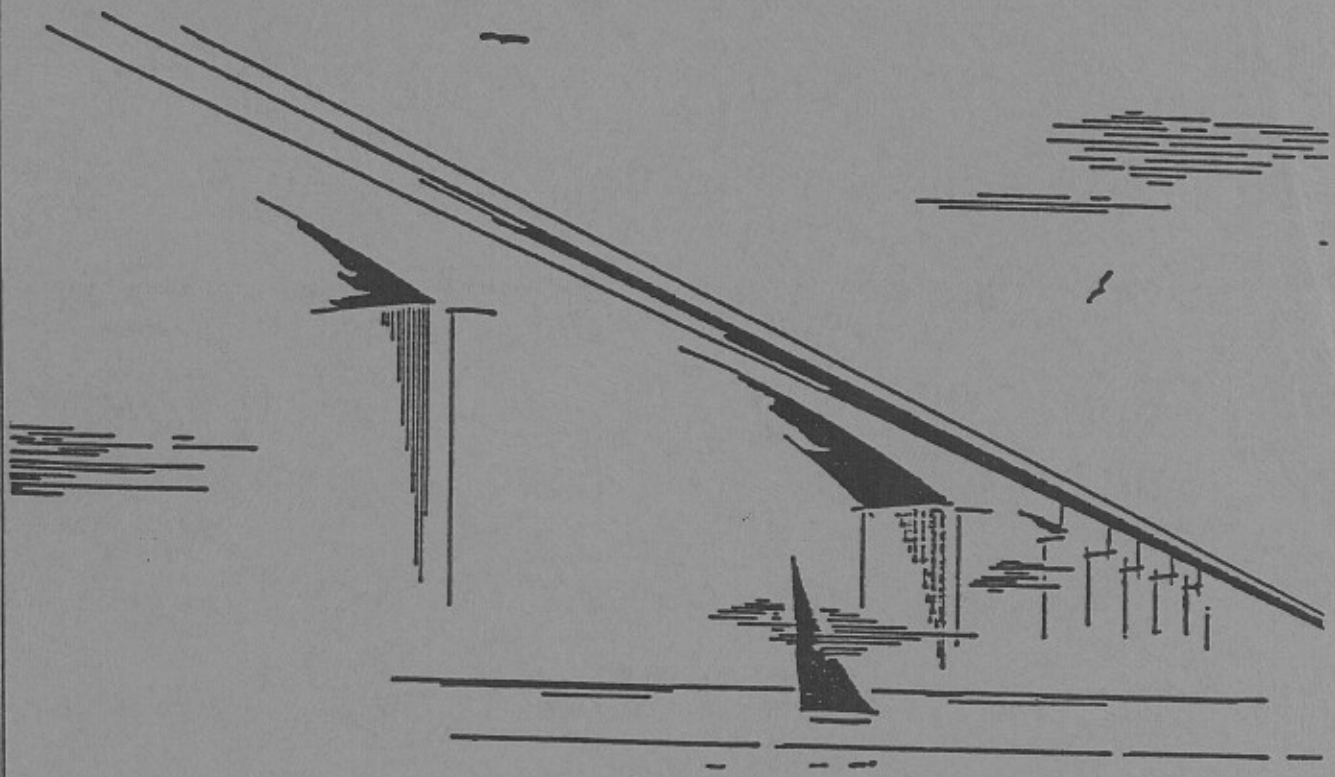

CONCRETE REMOVAL

BY VOLUME FOR

STRUCTURE REHABILITATION

CONCRETE REMOVAL BY VOLUME

FOR STRUCTURE REHABILITATION

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Summary

This report describes the volume method of measurement for payment to be used to administer removal of concrete which is scaled, delaminated or has corrosion potentials more negative than -0.35 volts. Separate tender items for the volume method are required for the various parts of the structure based on production rates. The depth of removal for components is to be specified as an average depth with a ± 10 mm tolerance.

The crew hour method is only to be used when cover meter survey data, concrete cores or original structure drawings do not provide sufficient data on concrete cover to reinforcing steel.

1. Introduction

The measurement for payment for the removal of spalled and delaminated concrete for structure rehabilitation has been, until 1988, by the crew hour method. A recent change in policy, that specifies the removal of concrete to 25 mm below the reinforcing steel in areas of spalls, delaminations and areas of corrosion potential more negative than -0.35 volts, has made the payment for the removal of concrete by area and volume methods feasible.

A number of contracts have been prepared using the area method; however, after considerable discussion it was decided that the volume method would be the preferred method and should be used exclusively in future contracts.

This report describes the reasoning used to develop the recommendations for the volume method. The method to be used for specifying depth of removal, the new tender items required and the guidelines for contract preparation and administration are also discussed.

2. General

The Contractor has to take the following factors into consideration when determining the bid price for concrete to be removed by area or volume.

- Soundness of cover concrete.
- Quality of concrete around reinforcing steel.
- Location of concrete removal.

In spalled and delaminated areas of removal, the concrete over the reinforcing steel will be relatively easy to remove. Where the Contractor is required to remove concrete based on half-cell survey results, the Contractor may have to increase his unit bid price depending on the extent of sound concrete in areas of corrosion potential more negative than -0.35 volts. On asphalt covered decks, where insufficient sawn samples or cores were taken during the condition survey, the contractor will probably assume that the cover concrete in these areas is generally sound when preparing his bid.

The quality of the concrete around the reinforcing steel may be the most difficult factor to predict if no cores have been taken for compressive strength tests during the condition survey on the components to be repaired. The bidder may be able to get some idea of the quality of concrete by a visual assessment and by hammer tapping the concrete during a site visit; however, the contractor probably will bid this work assuming that the concrete around the reinforcing steel is of fair to good quality.

The location of the removal area (ie. vertical, overhead, or underfoot) is a major consideration when determining production rates for concrete removal. Appendix D contains some concrete removal statistics that illustrate the large differences in production rates from deck surface removal and substructure removals. The large variations for the deck surface can be attributed to variations in work unit efficiency and quality of cover concrete.

Therefore, to get the best price for concrete removal by area and volume methods, a proper condition survey should be carried out and the work should be divided into separate items based on production rates.

3. Measurement For Payment

The main problem with the crew hour method is that the Contractor has no incentive to work efficiently. The problem is compounded due to insufficient Ministry inspections to monitor the workers. The area and volume methods give the Contractor incentive to work efficiently while requirements for inspection staff are reduced. The volume method is the preferred method because variations in concrete cover and rebar diameter are taken into account and surface removal of scaled concrete is included in the work. The three methods for measurement for payment along with their advantages and disadvantages are described below.

3.1 Crew Hour Method

Measurement for payment is by the number of hours that a work unit is in effective operation.

A five man work unit is usually specified for removal of concrete from bridge deck surfaces while a three man unit is specified for removal of concrete from soffit and substructure. Concrete is removed using 14 kg jack hammers and 7 kg chipping hammers.

Advantages

- If the work crew is efficient, this is the lowest cost method of removing concrete where the quality of the concrete is unknown at the bidding stage.

Disadvantages

- Contractor has no incentive to work efficiently.
- The onus of achieving effective production rates is on the Ministry.
- Ministry has inadequate staff to ensure that the work units are working effectively.

3.2 Area Method

Measurement for payment is by the area, in square metres, of the concrete removed. The size of work unit is the Contractor's responsibility; however, jack hammer and chipping hammer restrictions still apply.

Advantages

- Contractor has incentive to work efficiently.
- Ministry is not responsible for rate of removal.
- Ministry staffing requirements are reduced.
- Measurements for area and depth can be used to determine placement and abrasive blast cleaning quantities.

Disadvantages

- The condition survey may not always have sufficient information to get the best bid.
- Measurements are required to determine the area of removal as well as to determine if depth of removal deviates significantly from the contract requirements.
- Variations in concrete cover and rebar diameter are not taken into account.
- Surface removal of scaled concrete is by extra work.
- If depth of removal is significantly greater than specified in the contract, the contractor may submit a claim due to the larger volume of removal.

3.3 Volume Method

Measurement for payment is by the volume, in cubic metres, of the concrete removed. The size of work unit is the Contractor's responsibility; however, jack hammer and chipping hammer restrictions apply.

Advantages

- The Contractor has incentive to work efficiently.
- The Ministry is not responsible for rate of removal.
- Ministry staffing requirements are reduced.
- Measurements to determine the volume can be used to determine placement and abrasive blast cleaning quantities.
- Variations in concrete cover and rebar diameter are taken into account.
- Surface removal of scaled concrete can be included in the work.

Disadvantages

- The condition survey may not always have sufficient information to get the best bid.
- Measurements are required to determine the volumes.
- If the depth of removal is significantly less than specified in the contract, the contractor may submit a claim because the concrete may be more difficult to remove.

4. Specifying Depth of Removal

The method of specifying depth of removal to a fixed depth and to pay for removal of additional concrete by extra work or crew hour should no longer be used. Since the Contractor bases his bid on removing concrete to 25 mm below the reinforcing steel, the depth of removal should be specified as an average depth of removal with a $\pm$ 10 mm tolerance. The reasons for preferring the average depth method over the fixed depth method and a description of both methods are given below.

4.1 Fixed Depth Method

With this method, concrete is removed to a specified depth regardless of the variations in concrete cover and rebar diameter.

The main problem with this method is that the Contractor bases his bid on removing concrete to below the top mat of reinforcing steel. However, in areas of high concrete cover, he only has to remove concrete to the specified depth; the additional concrete removal to achieve 25 mm clearance below reinforcing steel will be by crew hour or extra work. As a result, the Contractor may have a "windfall" profit as the majority of the concrete may be the easy to remove cover concrete.

This method also requires two sets of measurements by the construction staff; one set is required to verify that the specified depth has been achieved while the other set is required to determine placement quantities. The administration requirement of the contract is increased further by the force account for the additional removal of concrete.

4.2 Average Depth Method

With this method, the average depth of removal for a component is calculated after the removal operation is completed. All unsound concrete, excluding concrete with surface scaling, is removed to 25 mm below the reinforcing steel regardless of variations in concrete cover and rebar diameters. The average depth would be specified with a 10 mm $\pm$ tolerance to facilitate estimating by the designer. The procedure for calculating the average depth of removal by the designer is described in Appendix A2. An example of calculating actual average depth by construction staff is contained in Appendix C.

The advantage of the average depth method over the fixed depth method is that in areas of high concrete cover, the Contractor has to remove the concrete to 25 mm below the reinforcing steel. If the actual average depth of removal is deeper than the design average by more than 10 mm, the Contractor may not have a basis for a claim as the additional concrete usually is the relatively easy to remove cover concrete and he is allowed heavier hammers to remove it.

If the actual average depth of removal is much lower than estimated due to low concrete cover, the Contractor might submit a claim if the actual average depth of removal is less than the design average depth by more than 10 mm. The claim would be based on the fact that the majority of the concrete is the relatively expensive to remove concrete surrounding the reinforcing steel. However, even if the Contractor would be successful with his claim, the Ministry would save money due to the lower tender quantity involved.

5. New Tender Items

New tender items are required for concrete removal by volume because production rates for concrete removal vary depending on the location and size of equipment permitted for the work. Appendix D illustrates the large variations of production rates between deck work and substructure work.

Separate tender items, based on production rates, will minimize claims due to overruns as the actual unit cost of removal for the tender item will remain unchanged.

5.1 Surface Removals

The tender items listed below apply to removal of scaled and delaminated concrete and concrete in areas where corrosion potentials of the reinforcing are more negative than -0.35 volts. The Contractor is restricted to 14 kg jack hammers and 7 kg chipping hammers for this removal.

Concrete Removal	- Structure ..... m^3	-	OPSS 930
Concrete Removal	- Deck Surface .. m^3	-	OPSS 930
Concrete Removal	- Deck Soffit ... m^3	-	OPSS 930

The above items are to be used where concrete cover to reinforcing steel can be determined from the original structure drawings, concrete cores or from a cover meter survey. If concrete cover to reinforcing steel cannot be obtained, the existing crew hour items should be used; however, every effort should be made to minimize the use of crew hour items.

5.2 Full Depth and Fixed Depth Removals

The tender items listed below apply to removal of concrete to a fixed depth or full depth as is the case when removing concrete to create blockouts for expansion joints or when concrete components are to be partially or completely replaced.

Concrete Removal	- Full Depth ... m^3	-	OPSS 510
Removal of Structure	- ... Lump Sum	-	OPSS 510

The work administered by the above tender items differs from the items described in Section 5.1 in that heavier equipment may be used to facilitate concrete removal.

6. Contract Preparation

Guidelines for preparing contract documents, including the special provisions required, are described in Appendix A and B. The appendices not only address concrete removal but also provide guidelines for other items that are effected by the new policy on concrete removal.

7. Contract Administration

7.1 Measuring Depths

The following guidelines are recommended to facilitate measuring the depth of removal and to help determine where the measurements should be taken.

- The depth at any given point should be measured from the bottom of a straight edge to the top of the reinforcing steel in the top layer. This depth plus rebar diameter plus 25 mm gives the total depth of removal at that point. This method minimizes any disputes due to the irregular concrete surface caused by the jack hammers.
- The maximum distance between measurements should be 2 metres.

- The slope at the perimeter of the removal area should be treated as a vertical face at the sawcut for the purpose of determining average depth.
- The localized removal required below the second layer of reinforcing steel should not be measured but is included in the unit price.

7.2 Calculating Weighted Average Depth

The weighted average depth of removal for each category of components is calculated by the following formula.

$$\text{Weighted Average Depth of Removal} = \frac{\text{Total Volume of Removal}}{\text{Total Area of Removal}},$$

where the areas with exposed rebars are measured.

The volume of concrete removal due to scaling with no reinforcing steel exposed is not included in this calculation. An example of calculating the average depth of removal is contained in Appendix C.

7.3 Claims and Negotiations

As noted in Section 4.2, the Contractor might submit a claim if the actual average depth of removal is less than the design average by more than 10 mm. On the other hand, the Ministry may want to negotiate a price reduction for components where the actual average depth of removal is deeper than the design average by more than 10 mm, due to excessive concrete cover; especially, if the cover concrete is fairly easy to remove. Therefore, when assessing any claim, the Ministry should review the overall concrete removal operation for the structure before determining the amount of compensation.

Negotiations for a price reduction should always be carried out in the following cases.

- When the requirement for removing concrete below the second layer of reinforcing steel is waived during construction.
- When the contract drawings specify concrete removal in areas with corrosion potential more negative than -0.35 volts and this requirement is waived during construction.

8. Conclusion

The volume method of measurement for payment for concrete removed is to be used in future contracts to administer removal of scaled and delaminated concrete and concrete in areas with corrosion potential more negative than -0.35 volts. The crew hour method should only be used when cover meter survey data, concrete cores or original structure drawings do not provide sufficient data on concrete cover to reinforcement.

The volume method would give the Contractor incentive to work efficiently while the Ministry staffing requirements for monitoring of the work will be significantly reduced. The measurements for concrete removal can also be used to determine placement quantities.

Contracts for the 1989 construction season have a mixture of crew hour, area and volume methods. The contracts using the volume method should be monitored closely and any recommendations for improving the policy or special provisions should be made early so that revisions to contract documents for the 1990 contracts, can be made prior to advertising.

APPENDIX A

ESTIMATING QUANTITIES FOR DESIGN OF REHABILITATION CONTRACTS

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APPENDIX A1

SCARIFYING - OPSS 930

I N D E X

1.1 General

Scarifying is required prior to the placement of a concrete overlay on bridge decks and sidewalks. Scarifying is done to remove surface concrete which may be contaminated and to provide a surface texture suitable for the application of the overlay. Normally, the depth of scarifying is specified as 6 mm to 10 mm. The depth of scarifying may be increased to remove surface scaling and other surface defects provided there is adequate concrete cover to the reinforcing steel.

1.2 Tender Item

Scarifying

1.3 Specifications

Details of the work of scarifying is contained in OPSS 930.

1.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design Estimating and Documentation Manual are applicable to this tender item.

A non-standard special provision is required when:

- a concrete overlay is required for sidewalks and curbs and the work of scarifying is to be included under this item;
- the depth of scarifying specified in the contract drawings differs from the tolerance given in the specifications.

1.5 Computation

1.5.1 Source of Information

The main sources of information are the original structure drawings, field note books, contract drawings and detailed deck condition survey reports.

1.5.2 Method of Calculation

The unit of measurement for scarifying is square metre based on the horizontal measurement.

Scarifying quantities are computed from the latest structure drawings or field measurements. The calculation should be compared with areas given in the Detailed Deck Condition Survey.

The area of existing expansion joint end dams shall not be measured for payment.

1.6 Documentation

The extent of scarifying shall be shown on the drawings. Depth of scarifying should also be shown when the required depth deviates from the specifications.

Where documentation of scarifying is complicated by the requirements that some locations require an extra depth of removal, it is important that the contract drawings clearly show the extent of these areas along with the required depth of removal for each area.

The removal of scaled concrete should be administered under the removal of concrete items when there is inadequate concrete cover to reinforcing steel or the limits of scaling cannot be predetermined.

The scarifying quantities for sidewalks, curbs and decks shall appear on the Quantities - Structure Sheet in separate columns and shall be combined into one total for the tender item "Scarifying".

1.7 Documentation Accuracy

Quantities for scarifying are to the nearest square metre.

APPENDIX A2

REMOVAL OF CONCRETE - OPSS 930
CONCRETE REMOVAL - STRUCTURE - OPSS 930
CONCRETE REMOVAL - DECK SURFACE - OPSS 930
CONCRETE REMOVAL - DECK SOFFIT - OPSS 930

I N D E X

2.1 General

The removal of concrete involves the removal of delaminated and unsound concrete using airhammers.

The depth of removal extends to 25 mm below the top layer of reinforcing steel within the entire demarcated areas of spalls and delaminations and within areas of bridge decks with corrosion potential more negative than 0.35 volts. In addition to the above, localized removal of concrete is required to a depth of 25 mm below the second layer of reinforcing steel.

The procedure for concrete removal for bridge decks applies to other components except that concrete removal in areas with corrosion potential more negative than -0.35 volts applies only when a half-cell survey has been carried out.

The removal of very severely scaled concrete and other deteriorated concrete shall extend to 25 mm below top layer of reinforcing steel only when the reinforcing steel is exposed. Normally, the removal of scaled concrete shall extend to the depth of sound concrete and to a sufficient depth for patch repairs. Where a bridge deck is to receive a concrete overlay, the removal of scaled concrete should be included with the scarifying item; provided that concrete cover is not a problem and extent of scaling can be predetermined.

Separate tender items are required to separate work carried out on the deck surface, deck soffit and other parts of the structure due to the difference in production rates and access requirements.

For cathodic protection rehabilitations concrete shall be removed based on the delamination survey. Sound concrete in areas of corrosion potential more negative than -0.35 volts does not have to be removed. Cathodic protection stops active corrosion and, therefore, prevents further delaminations.

The area of corrosion activity on concrete/timber composite decks is usually extensive compared to the area of delamination; therefore, the removal of concrete should be based on delamination survey results only.

The volume method of measurement for payment will normally be used for this work while the crew hour method may be required on rare occasions.

In the case of thin deck slabs where the thickness of the deck is less than 175 mm and the concrete is not of good quality, serious consideration should be given to full depth removal in the areas of unsound concrete; especially, if partial depth removal is expected to extend over more than half of the deck depth. The condition of soffit for thin deck slabs should also be reviewed to determine if full depth concrete removal is required for areas of unsound concrete coinciding with concrete removal on deck surface. Contract drawings should indicate full depth deck removal for these areas. The removal of full depth concrete should be administered under OPSS 510 item and quantities should be revised accordingly. Provisions should be made in the contract documents for traffic protection or traffic control when there is traffic beneath the structure.

2.2 Measurement For Payment by Volume

2.2.1 General

The volume method should be used when reinforcement diameter and concrete cover to reinforcing steel can be determined from original structure drawings, concrete cores or concrete cover meter readings. If the original structure drawings are used to determine concrete cover, the cover to reinforcing steel should be confirmed, where practical, in areas of removal that are accessible.

2.2.2 Tender Items

The following item descriptions should be selected for use according to their suitability when completing the list of tender items.

Description	Condition For Use
Concrete Removal - Structure	- Applies to all structure components except that separate items for deck surface and deck soffit will be usually required.
Concrete Removal - Deck Surface	- Applies to deck surface, sidewalks and curbs. - Where quantity for either this item or the item "Concrete Removal - Structure" is less than 1 m^3, the work for both items should be administered under the item "Concrete Removal - Structure".
Concrete Removal - Deck Soffit	- Applies to deck soffit; concrete beams may be included with this item if removal is primarily in the beam soffits. - Where quantity for either this item or the item "Concrete Removal - Structure" is less than 1 m^3, the work for both items should be administered under the item "Concrete Removal - Structure".

If the total volume of removal for the bridge is less than 1 m^3, the removal of concrete may be administered under "Extra Work" procedures. Alternatively, this work may be included with the concrete patching item.

2.2.3 Specifications

Details of the work of removal of concrete from bridge decks previously contained in OPSS 930 are now addressed by special provisions.

2.2.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

Non-standard special provision 930 D1 contained in Appendix B, and standard SP 109F10, should be completed and inserted in the contract.

2.2.5 Computations

2.2.5.1 Sources of Information

The main sources of information are the detailed condition survey reports, the delamination and cover meter surveys carried out by Regional Structural Section staff and the original structure drawings.

2.2.5.2 Adjustment Factors

When calculating quantities for concrete removal, the volume of concrete removed is increased by 10% for every year between the year of the condition survey and the year of construction to take into account any deterioration that takes place during that period.

On exposed surfaces, where removal of concrete is based on the sounding method only, the initial quantity is increased by 25% to take into account imminent delaminations in areas of sound concrete where corrosion potential is more negative than -0.35 volts. Additional removal of concrete due to corroded reinforcing steel beyond the delaminated area is also taken into account by this adjustment factor.

On asphalt covered decks, there may be areas of the deck that are delaminated or scaled but the corrosion potential of the reinforcing steel is in the acceptable range. The area of corrosion potential more negative than -0.35 volts is increased by 10% to allow for this unsound concrete. Where significant deterioration is suspected in areas with low corrosion potential, additional investigation should be carried out, where practical, to improve the design estimate.

2.2.5.3 Average Depth of Removal

The average cover to reinforcing steel and rebar diameter is required to calculate the average depth of removal.

Where possible, the average cover should be determined from cover meter readings taken in the largest areas of removal. Concrete cover may also be determined from concrete cores provided that the designer is reasonably confident that the cores have been taken through the first rebar in the top mat.

If cover meter readings or cores are unavailable and cover measurements cannot be taken on spalled areas, then the cover given in original structure drawings may be used. As deterioration of concrete appears most frequently in areas of low concrete cover, the cover given in the drawings should be reduced by 10 mm when calculating the average depth.

The average reinforcement diameter should be determined from original structure drawings. The reinforcement diameters in the top layer of reinforcing steel in the largest areas of removal should be used in the calculation.

2.2.5.4 Method of Calculation

The notations that represent the areas and depths for different types of deterioration and the number of years between condition survey and construction are described below. The values for these notations should be determined for each component before proceeding with calculations for concrete removal.

A_{DLM} = area, m^2, of delaminations and spalls (include areas of very severe scaling where reinforcing steel will be exposed during removal).

A_{CP} = area, m^2, of deck with corrosion potential more negative than -0.35 volts.

A_{LAP} = area, m^2, of overlapping defects for A_{DLM} and A_{CP}.

A_{SCL} = area, m^2, of medium to very severe scaling (exclude areas that will be removed by scarifier for concrete overlays or are included in A_{DLM} and A_{CP}).

D_{SCL} = Average depth of scaling for A_{SCL} in metres.

D_{AVG} = Average theoretical removal depth, for A_{DLM} and A_{CP} in metres; calculated as follows:

(i) Where average concrete cover is calculated from field measurements.

D_{AVG} = (average concrete cover, mm + average top bar diameter, mm + 25 mm under top bar - 8 mm scarifying, if applicable) X .001.

(ii) Where concrete cover to reinforcing steel is taken from original structure drawings.

D_{AVG} = (theoretical concrete cover, mm - 10 mm + average top bar diameter, mm + 25 mm - 8 mm scarifying, if applicable) X .001

n = the number of years between the condition surveys and construction.

The procedure for calculating the quantity for concrete removal for bridge deck surfaces and other concrete components is given in Tables A2-1 to A2-6. A separate calculation is required for each component. The quantities are then combined under the separate tender items described in Section 2.2.2 as follows:

(a) Concrete Removal - Deck Surface

Calculate V_{DS}, the volume, m^3, of concrete to be removed from the deck (V_{DC}), sidewalks (V_{SW}) and curbs (V_{CRB}).

$$V_{DS} = V_{DK} + V_{SW} + V_{CRB}$$

(b) Concrete Removal - Deck Soffit

Calculate V_{SOF}, the volume, m^3, of concrete removed from the deck soffit (V_{DS}) and beams (V_{BM}).

$$V_{SOF} = V_{DS} + V_{BM}$$

(c) Concrete Removal - Structure

Calculate V_{STR}, the volume, m^3, of concrete removed from the structure excluding the quantities for deck surface and deck soffit.

$$V_{STR} = (V_{CPT}1 + V_{CPT}2 \ldots + V_{CPT}N)$$

where each number represents a different category of components.

Table A2 - 1 - Exposed Concrete Decks
Concrete Removal Based on Corrosion Potential and Delamination Surveys
(Table shall not be used for cathodic protection rehabilitation)

Calculate A_{RBR}, the area, m^2, of concrete to be removed below the reinforcing steel.

$$A_{RBR} = (A_{DLM} + A_{CP} - A_{LAP}) \times 1.1^n$$

Calculate V_{DK}, the volume, m^3, of concrete to be removed from the deck.

$$V_{DK} = (A_{RBR} \times D_{AVG}) + (A_{SCL} \times D_{SCL})$$

Table A2 - 2 - Exposed Concrete Decks
Concrete Removal Based on Delamination Survey

Calculate A_{RBR}, the area, m^2, of concrete to be removed to below the reinforcing steel.

$$A_{RBR} = 1.25\ A_{DLM} \times 1.1^n$$

Calculate V_{DK}, the volume, m^3, of concrete to be removed from the deck.

$$V_{DK} = (A_{RBR} \times D_{AVG}) + (A_{SCL} \times D_{SCL})$$

Table A2 - 3 - Asphalt Covered Decks
Concrete Removal Based on Corrosion Potential and Delamination Surveys
(Table shall not be used for cathodic protection rehabilitation)

Calculate A_{RBR}, the area, m^2, of concrete to be removed to below the reinforcing steel.

$$A_{RBR} = 1.1\ A_{CP}\ X\ 1.1^n$$

Calculate V_{DK}, the volume, m^3, of concrete to be removed from the deck.

$$V_{DK} = A_{RBR}\ X\ D_{AVG}$$

Table A2 - 4 - Asphalt Covered Decks
Concrete Removal Based on Delamination Survey

Estimate A_P, the area, m^2, of unsound concrete in area A_{CP}

Determine N_T = the total number of cores and sawn samples taken in area A_{CP}.

N_P = the number of cores and sawn samples indicating delaminated or deteriorated concrete in area A_{CP}.

Calculate $A_P = N_P/N_T\ X\ A_{CP}$ (use a minimum value of 0.5 for N_P/N_T if insufficient cores and sawn samples have been taken)

Calculate A_{RBR}, the area, m^2, of concrete to be removed to below reinforcing steel

$$A_{RBR} = [0.1\ A_{CP} + A_P]\ 1.1^n$$

Calculate V_{DK}, the volume, m^3, of concrete to be removed from the deck.

$$V_{DK} = A_{RBR}\ X\ D_{AVG}$$

Table A2 - 5 - Concrete Components Excluding Deck Surfaces
Concrete Removal Based on Delamination Survey

Each component requires a separate calculation.

Calculate A_R the area, m^2, of concrete to be removed below the reinforcing steel.

$$A_R = 1.25\ A_{DLM} \times 1.1^n$$

Calculate V_{CPT}, the volume, m^3, of concrete to be removed from the component.

$$V_{CPT} = (A_R \times D_{AVG}) + (A_{SCL} \times D_{SCL})$$

Table A2 - 6 - Concrete Components Excluding Deck Surfaces
Concrete Removal Based on Corrosion Potential and Delamination Surveys
(Table shall not be used for cathodic protection rehabilitation)

Each component requires a separate calculation.

Calculate A_R the area, m^2, of concrete to be removed below the reinforcing steel.

$$A_R = (A_{DLM} + A_{CP} - A_{LAP}) \times 1.1^n$$

Calculate V_{CPT}, the volume, m^3, of concrete to be removed from the component.

$$V_{CPT} = (A_R \times D_{AVG}) + (A_{SCL} \times D_{SCL})$$

2.2.6 Documentation

2.2.6.1 General

The Detailed Condition Survey and original structure drawings shall be made available for reviewing during the tendering period. Drawings indicating the location of deterioration, corrosion potential survey results, and cover meter survey shall be included with the contract documents whenever possible. The location of deterioration should always be shown on contract drawings when access to work area is a consideration and when this information is not contained in the Condition Survey.

Where more than one method of measurement for payment is used, the contract documents shall clearly indicate the areas of removal that apply to each.

Drawings shall indicate that the perimeter of the removal area shall be sawcut to a depth of 25 mm (sawcutting is not required if the concrete surface is refaced or overlayed).

The average depth of removal to below reinforcing steel, with a ± 10 mm tolerance, should be shown on the drawings for each component. The minimum depth of removal in scaled areas should also be shown.

2.2.6.2 Concrete Removal Detail

A typical concrete removal detail and a table showing area and depth of removal for each component should be included in the contract drawings. An example is given in Figures 1 and 2.

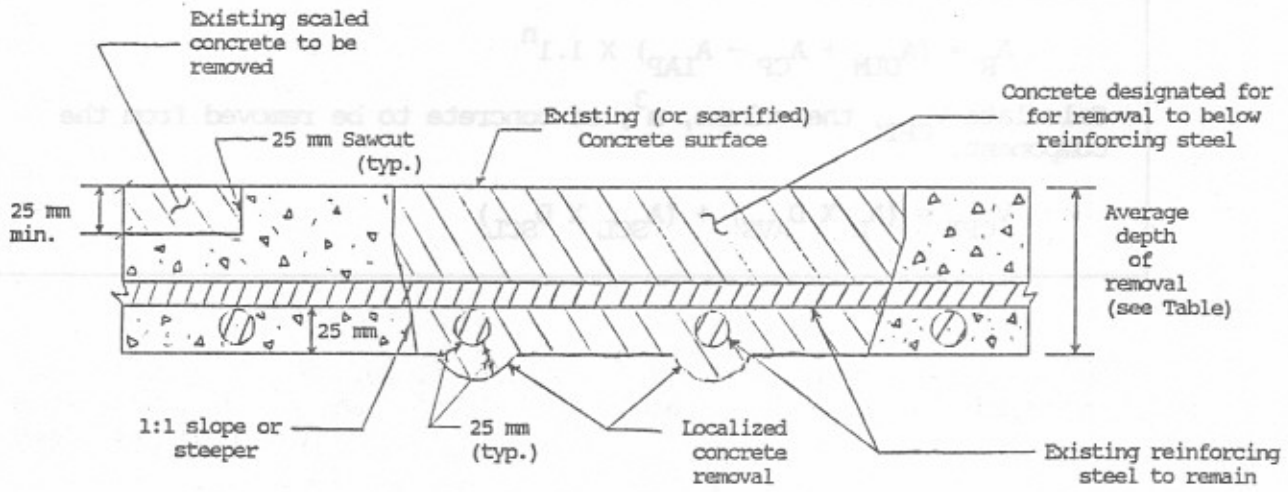


Figure 1 - CONCRETE REMOVAL DETAIL

Item Description	Component	Average Depth of Removal	Area of Removal
Concrete Removal-Deck Surface	Deck Surface Sidewalks	80 ± 10 mm 70 ± 10 mm	76 m^2 10 m^2
Concrete Removal-Structure	Parapet Walls Beams Abutments Deck Facia Piers	65 ± 10 mm 60 ± 10 mm 90 ± 10 mm 75 ± 10 mm 80 ± 10 mm	25 m^2 5 m^2 21 m^2 15 m^2 54 m^2
Concrete Removal-Deck Soffit	Deck Soffit	70 ± 10 mm	27 m^2

Figure 2 - CONCRETE REMOVAL TABLE (Example)

2.2.7 Documentation Accuracy

Quantities for concrete removal, by volume, are to the nearest 0.01 m^3.

2.3 Measurement For Payment By Crew Hour

2.3.1 General

The crew hour method should be used on the rare occasion where original structure drawings are not available and a cover meter survey cannot be carried out due to time constraints or other reasons. If a depth of removal can be determined, then the volume method should always be used.

2.3.2 Tender Items

The following item descriptions and their corresponding units of measurement should be selected for use according to their suitability when completing the list of tender items.

Description	Unit	Condition for Use
Removal of Concrete	Crew Hour (5-man)	- Used for removal of concrete from bridge deck surface, sidewalks and concrete barrier systems. If total quantity for the item is less than 30 crew hours, the work should be administered under the 3-man crew hour item.
Removal of Concrete	Crew Hour (3-man)	- Normally used for removal of concrete from deck soffit, beams and substructure. If total quantity for item is less than 30 crew hours, the work may be included with the 5-man crew hour item if that item is required.

If the total number of crew hours for the structure is less than 20, the removal of concrete may be administered under "Extra Work" procedures. Alternatively, this work may be included with the concrete patching item.

2.3.3 Specifications

Details of the work of removal of concrete from bridge decks previously contained in OPSS 930 are now addressed by special provisions.

2.3.4 Special Provisions

The designer should investigate whether any standard special provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item. Despite its warrant, Special Provision 999$10 is not to be included in the contract with this item.

Non-standard special provisions for concrete removal are contained in Appendix B. Special provision 930 D1 should be completed and included in the contract. Special provision 930 D4 and 930 D5 shall be inserted as appropriate.

2.3.5 Computations

2.3.5.1 Sources of Information

The main sources of information are the detailed condition survey reports, the delamination and cover meter surveys carried out by Regional Structural Section Staff and the original structure drawings.

2.3.5.2 Method of Calculation

Before calculating the crew hour quantities, the volume of removal for each component must be calculated. The procedure for calculating these volumes is described in Tables A2-1 to A2-6.

(a) Five Man Work Unit

Calculate the total volume, V_{TD} in m^3 of concrete to be removed from deck surfaces (V_{DK}), sidewalks (V_{SW}), curbs (V_{CRB}) and barrier systems $V(_{BAR})$.

$$V_{TD} = V_{DK} + V_{SWC} + V_{CRB} + V_{BAR}$$

Calculate, C_D, the number of crew hours (5 man) required.

$$C_D = V_{TD}/PR$$

Where PR = the production rate for a 5 mm crew on bridge deck removal.

= 0.08 m^3/crew hour (5 man) when concrete to be removed appears to be of good quality.

= 0.125 m^3/crew hour (5 man) when concrete to be removed appears to be of poor quality (ie. disintegrating or low compressive strength).

(b) Three Man Work Unit

Calculate the total volume, V_{TS} in m^3, of the concrete to be removed from the deck soffit and substructure.

$$V_{TS} = V_{CPT}1 + V_{CPT}2 \ldots V_{CPT}N$$

Where each number represents a different category of components for the soffit and substructure.

Calculate, C_S, the number of crew hours (3 man) required.

$$C_S = V_{TS}/PR$$

Where PR = the production rate of a 3 man crew in deck soffit and substructure removals.

$$= 0.04 \ m^3/\text{crew hour (3 man)}$$

2.3.6 Documentation

Where the volume method of measurement is also used for the structure, the contract documents should clearly indicate which components the crew hour method applies to.

The typical location of deterioration and requirements for sawcutting should be shown on contract drawings.

2.3.7 Documentation Accuracy

Quantities for concrete removal, by crew hour, are to the nearest crew hour.

APPENDIX A3

RENTAL OF AIRHAMMER(S), (OPERATED) - OPSS 930

I N D E X

3.1 General

The rental of airhammer item is used in conjunction with the payment by crew hour item for removal of concrete.

The purpose of the item is to increase the flexibility and efficiency of the crew during construction.

It is not necessary to implement this item during construction if it is not required.

3.2 Tender Items

Rental of Airhammer(s) (Operated) - OPSS 930

3.3 Specifications

Details of the rental of airhammer item are contained in OPSS 930.

3.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item. Despite its warranty, special provision 999S10 is not to be included in the contract.

Non-standard special provision 930 D6, contained in Appendix B should be included in the contract when this item is required.

3.5 Computation

3.5.1 Source of Information

The crew hour quantities calculated for the item "Removal of Concrete".

3.5.2 Method of Calculation

The unit of measurement is by the hour that the airhammer is in effective operation.

The method of calculation is as follows:

a) If total estimated crew hour for both the 3-man and 5-man work units is less than a 100 crew hours.

   No item required.

b) If total estimated crew hours for both the 3-man and 5-man work units are between 100 and 300 crew hours.

   Calculate as 0.33 x total number of crew hours.

c) If total estimated crew hours for both the 3-man and 5-man work units exceed 300 crew hours.

Use 100 hours.

3.6 Documentation Accuracy

Quantities for rental of airhammer(s) operated are to the nearest hour.

APPENDIX A4

ABRASIVE BLAST CLEANING OF REINFORCING STEEL - OPSS 930

I N D E X

4.1 General

The abrasive blast cleaning of existing exposed reinforcing steel is required prior to the placement of a concrete overlay. Existing reinforcing steel that is epoxy coated shall not be blast cleaned.

This is a separate pay item in conjunction with concrete overlays. The abrasive blast cleaning of reinforcing steel is usually included with the concrete placement item for repairs to other concrete components. However, there may be instances where a separate pay item may be warranted for abrasive blast cleaning of reinforcing steel for these components as well.

Abrasive blast cleaning of structural steel that is to be in contact with new concrete shall be administered under the concrete placement item.

4.2 Tender Item

Abrasive Blast Cleaning Reinforcing Steel.

4.3 Specifications

Details of the work of abrasive blast cleaning are contained in OPSS 930.

4.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

A non-standard special provision is required to include the work of abrasive blast cleaning of reinforcing steel for areas other than the deck if they are to be included with this item.

4.5 Computation

4.5.1 Source of Information

The main sources of information are the detailed deck condition survey reports and, delamination and concrete surface deterioration surveys carried out by the Regional Structural Section Staff.

4.5.2 Method of Calculation

The unit of measurement for abrasive blast cleaning of reinforcing steel is by the square metre based on the horizontal area of deck over which reinforcing steel is exposed.

The area of exposed reinforcing has already been determined in the calculations for concrete removal from bridge decks described in Tables A2-1 to Table A2-4 of Appendix A2. A_{RBR} represents the area of exposed reinforcing steel requiring abrasive blast cleaning.

4.6 Documentation

Contract drawings should show typical spacing and diameter of reinforcing steel where abrasive blast cleaning is required if practical. In any case, original structure drawings should be made available for viewing, if available, during the tendering period.

4.7 Documentation Accuracy

Quantities of exposed reinforcing steel are to the nearest square metre.

APPENDIX A5

PLACE NORMAL SLUMP CONRETE OVERLAY - OPSS 930
PLACE LATEX MODIFIED CONCRETE OVERLAY - OPSS 930

I N D E X

5.1 General

Concrete overlays are usually placed on decks where the removal of concrete covers more than 10% of the deck area. Normal concrete or latex modified concrete are used for concrete overlays.

The placing of concrete in the areas of removal shall, normally, be included with the concrete overlay item. Where full depth deck patches are anticipated or where the continuous anode mesh cathodic protection system is used as the rehabilitation method, a separate item may be required for this work.

5.2 Tender Items

Place Normal Slump Concrete Overlay
Place Latex Modified Concrete Overlay

5.3 Specifications

Details of the work of placing all types of concrete overlays are contained in OPSS 930.

5.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

5.5 Computation

5.5.1 Source of Information

The main source of information is the calculations for removal of concrete, the latest structure drawings, contract drawings, field notebooks, data from engineering survey and detailed deck condition surveys.

5.5.2 Method of Calculation

The unit of measurement for concrete overlays is m^3, based on the volume placed and is calculated as follows.

Review calculations for concrete removal described in Tables A2-1 to A2-4 of Appendix A2 to determine volume of concrete removal, V_{DK}, in m^3 for the deck.

Determine the volume, V_{FDR}, m^3, of full depth deck removal, if any, administered by OPSS 510 items.

Estimate V_O the total volume, m^3, of concrete overlay.

$$V_O = 1.2\ (.001\ h\ A) + V_{DK} + V_{FDR}$$

Where A = Area of overlay in m^2

h = Nominal thickness, mm, of overlay from scarified surface.
Normally, 50 mm for latex modified concrete
60 mm for normal concrete

The volume of concrete overlay is increased by 20% to allow for correction of grade and crossfall.

The method of calculating the quantity of concrete can be improved significantly where existing elevations are known and screed elevations are calculated.

5.6 Documentation

Contract drawings should show the overlay thickness from the scarified surface and the limits of the concrete overlay in plan and cross section. Any geometric conditions which may affect the contractors' operations, choice of equipment, or number of placing operations shall also be detailed.

Screed elevations should be calculated and shown on contract drawings when existing elevations of concrete surface are known.

Where the final profile of wearing surface is higher or lower than the approaches to the structure, the treatment required for approaches shall be detailed on the drawings by either Structural or Planning and Design Sections.

5.7 Documentation Accuracy

Quantity of concrete overlays are to the nearest cubic metre.

APPENDIX A6

CONCRETE PATCHES IN DECK - OPSS 904, SP 904F03
CONCRETE PATCHES - CONCRETE - OPSS 904

I N D E X

6.1 General

Concrete patches are used for deck repair prior to installing a waterproofing membrane or cathodic protection. Concrete patches can be used on vertical faces if depth of repair exceeds 100 mm and shotcreting is uneconomical. The patch on a formed face may be overbuilt to achieve the 100 mm minimum depth.

Deck patches are usually included with the concrete overlay method of rehabilitation unless the continuous anode mesh method of cathodic protection is specified in the contract.

Concrete patches are not to be used to repair scaled areas on horizontal surfaces unless depth of repair is greater than 50 mm. Latex modified mortar or proprietary products should be used where the depth of repair is less than 50 mm. The work of abrasive blast cleaning of reinforcing steel is included with the patchwork while concrete removed is paid by a separate item.

6.2 Tender Item

The following item descriptions should be selected for use when completing the list of tender items.

Description	Condition for Use
Concrete Patches - Concrete	- Used for all components except that a separate item for bridge decks may be required.
Concrete Patches in Deck	- Used for bridge decks, curbs and sidewalks. - Where the quantity for this item or the item "Concrete Patches - Concrete" is less than 1 m^3, the work for both items should be administered under the item "Concrete Patches - Concrete".

6.3 Specifications

Details of the work of placing concrete are contained in OPSS 904.

6.4 Special Provisions

The designer should investigate if any other Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this item.

Details of the work of placing concrete in deck patches are contained in SP 904 F03.

The details of concrete patches - concrete should be covered by a non-standard special provisions that should address the following.

. specify the use of a super plasticizer if concrete is to be placed in area congested with reinforcing steel and in areas with poor access for placing of concrete;

. describe the components that the item applies to;

. specify maximum size of course aggregate usually 10 mm;

. specify curing requirements;

. include measurement for payment and basis of payment.

6.5 Computation

6.5.1 Source of Information

The main source of information are the delamination and surface deterioration survey by Regional Structural Sections, the latest structure drawings, contract drawings, field note books and detailed deck condition surveys.

6.5.2 Method of Calculation

The unit of measurement for concrete patches is by the m^3 based on the volume of concrete placed and is calculated as follows:

6.5.2.1 Concrete Patches in Deck

Review calculations or concrete removal described in Table A2-1 to A2-4 of Appendix A2 to determine the volume V_{VK} in m^3, of concrete to be removed from the deck surface.

Determine the volume, V_{FDR} in m^3, of full depth deck removal, if any; administered by OPSS 510 items.

Review calculations for concrete removal described in Table A2-5 and A2-6 of Appendix A2 to determine the volume, V_{SWK} and V_{CRB} in m^3, of the concrete removed from sidewalks and curbs.

Calculate V_T, the volume, m^3, of concrete required to patch the deck including sidewalks and curbs.

$$V_T = V_{DK} + V_{FDR} + V_{SWK} + V_{CRB}$$

6.5.2.2. Concrete Patches - Concrete

Review data used to determine concrete removal quantities for components excluding the deck that are to be patched with normal concrete. Sidewalks and curbs are also included with this item when deck patches are included with concrete overlays. The calculations for concrete removal are described in Tables A2-5 and A2-6 of Appendix A2.

Determine A_R, the area, m^2, and D_{AVG}, the depth in metres, for each component that is to be repaired with normal concrete.

(D_{AVG} should be 0.10 metre minimum to ensure 50 mm cover is achieved.)

Calculate V_T, the volume, m^3, of concrete required for concrete patches - concrete.

$$V_T = A_R1 \times D_{AVG}1 + A_R2 \times D_{AVG}2 \ldots + A_RN \times D_{AVG}N$$

Where each number represents a different component to be repaired with concrete.

6.6 Documentation

6.6.1 General

Where total volume for concrete patches for the structure is less than 1 m^3, the placement of concrete patches may be included with one of the other OPSS 904 items provided that the dimensions and locations of the patches are shown on the contract drawings. Otherwise, the work may be carried out under extra work provisions.

6.6.2 Concrete Patches in Deck

Where the total volume of concrete required is less than 2 m^3 per stage, consideration should be given to allow the contractor the option to use a proprietary product instead of normal concrete. This is especially useful for remote locations or where scheduling is tight and the structure has to be opened to traffic as soon as possible.

6.6.3 Concrete Patches - Concrete

OPSS 904 should be referred to in the specification column in the list of tender items of the D4 forms.

Drawings should show location of the repair area for substructure so that the bidder can determine access requirements and the most economical method of placing concrete. Locations of repair can be given by special provision instead of drawings where access and traffic protection are not significant considerations.

The quantities for concrete patches shall be given separately on the contract drawings for each component and shall be combined into one total for the tender item "Concrete Patches - Concrete".

6.7 Documentation Accuracy

Quantities for concrete patches are to the nearest cubic metre.

APPENDIX A7

LATEX MODIFIED SHOTCRETE - SP 920

I N D E X

7.1 General

Latex modified shotcrete is used for repairs to vertical and overhead concrete surfaces.

An alternative to latex modified shotcrete are proprietary products. These should only be specified if total volume of repair is less than 1.0 m^3 as they are very expensive.

The cost of mobilization for shotcrete (including test panels) is high and, therefore, when the quantity is less than 5 m^3 and where overhead work is a minor quantity (less than 0.5 m^3) repairs with normal concrete should be considered. Repairs with normal concrete can be made where depth of repair on vertical face is greater than 100 mm. Repairs to deck soffits on the deck slabs can also be made with normal concrete if access is provided from top of deck and superplasticized concrete is used.

When specifying shotcrete as the repair material, the designer should make sure that all areas of repair can be made accessible for proper application of the shotcrete.

7.2 Tender Item

Latex Modified Shotcrete.

7.3 Specifications

None at this time.

7.4 Special Provisions

Details of the work for surface preparation and placement of latex modified shotcrete are contained in Standard Special Provision 999F08.

The designer should investigate whether any other Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

7.5 Computation

7.5.1 Source of Information

The main sources of information are the delamination and concrete surface deterioration surveys by Regional Structural Sections, the latest structure drawings, contract drawings, field notebooks and detailed condition surveys.

7.5.2 Method of Calculation

The unit of measurement for latex modified shotcrete is by the m^3 based on the volume of shotcrete placed and is calculated as follows:

a) Review data used to determine concrete removal quantities for components that are to be repaired with shotcrete. The calculations for concrete removal are described in Table A2-5 and A2-6 of Appendix A2.

Determine A_R and A_{SCL}, the area, m^2, for each component to be repaired with shotcrete.

Determine D_{AVG}, the depth in metres for each A_R

(D_{AVG} should be 0.10 metre minimum to ensure that 50 mm cover is achieved.)

b) Calculate V_{SCL}, the volume, m^3, of shotcrete required to repair scaled areas.

$$V_{SCL} = (A_{SCL}1 + A_{SCL}2 \ldots\ldots A_{SCL}N) \times 0.050 \text{ m}$$

c) Calculate VT, the volume, m^3, of shotcrete required for all repairs.

$$VT = V_{SCL} + [(A_R1 \times D_{AVG}1) + (A_R2 \times D_{AVG}2) + \ldots\ldots (A_RN \times D_{AVG}N)]$$

where each number represents a different component to be repaired with concrete.

7.6 Documentation

The contract drawings should show the location of typical repair areas and final surface.

The quantities for latex modified shotcrete shall be given separately for vertical and overhead work and shall be combined into one total for the tender item "Latex Modified Shotcrete".

SP 999F08 should be completed by specifying Option A or B as the measurement for payment method.

Where more than one structure is to be repaired with shotcrete on the same contract, the tender item for Latex Modified Shotcrete Test Panels should be included with the planning and design tender items. Only one set of test panels is required in the contract as the special provision clearly states that the test panels shall be constructed using the same personnel, equipment and materials as those to be used for the actual work.

7.7 Documentation Accuracy

Quantities for latex modified shotcrete are to the nearest 0.1 cubic metre.

APPENDIX A8

ABRASIVE BLAST CLEANING OF CONCRETE SURFACES AND REINFORCING STEEL - SP 920

I N D E X

8.1 General

The abrasive blast cleaning of concrete surfaces and reinforcing steel is required as a separate "pay" item for latex modified shotcrete.

However, if concrete patch repairs are carried out in conjunction with latex modified shotcrete, the abrasive blast cleaning for concrete patch repairs may be included with this item.

8.2 Tender Item

Abrasive Blast Cleaning Concrete Surfaces and Reinforcing Steel.

8.3 Specifications

None at this time.

8.4 Special Provisions

Details of the work of abrasive blast cleaning concrete surfaces and reinforcing steel are contained in Standard Special Provision 999F08.

The designer should investigate whether any other Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

A non-standard special provision is required if abrasive blast cleaning of areas to be repaired with concrete are to be included with this tender item.

8.5 Computation

8.5.1 Source of Information

The main sources of information are the calculation for the quantity of latex modified shotcrete required, contract drawings, field notebooks and detailed condition surveys.

8.5.2 Method of Calculation

The unit of measurement for abrasive blast cleaning concrete surfaces and reinforcing steel is by the m^2 based on the plan area of surface to be repaired with latex modified shotcrete.

Calculate A_{CR}, the area, m^2, of concrete surfaces and reinforcing steel that requires abrasive blast cleaning as follows:

Refer to the shotcrete calculations (Appendix A7) and obtain the values A_R and A_{SCL} for each component.

Calculate $A_{CR} = (A_R1 + A_R2 \ldots + A_RN) + (A_{SCC}1 + A_{SCC}2 \ldots + A_{SCC}N)$

where each number represents a different component to be repaired with shotcrete.

8.6 Documentation

The contract documents should show location of typical repair areas.

The quantities for abrasive blast cleaning of concrete surfaces with exposed reinforcing steel and concrete surfaces with no reinforcing steel exposed shall be given separately and shall be combined into one total for the tender item "Abrasive Blast Cleaning Concrete Surfaces and Reinforcing Steel".

The contract drawings shall show typical spacing and diameter of reinforcing steel where abrasive blast cleaning is required, if practical.

8.7 Documentation Accuracy

Quantities for abrasive blast cleaning concrete surfaces and reinforcing steel are to the nearest square metre.

APPENDIX A9

REINFORCING STEEL - OPSS 905
COATED REINFORCING STEEL - OPSS 905

I N D E X

9.1 General

Reinforcing steel is added to the structure for modification or rehabilitation of concrete components.

9.2 Tender Items

Reinforcing Steel
Coated Reinforcing Steel

9.3 Specifications

Details of the work of placing reinforcing steel are contained in OPSS 905.

9.4 Special Provisions

The designer should investigate whether any Standard Special Provisions in Chapter E of the Contract Design, Estimating and Documentation Manual are applicable to this tender item.

9.5 Computation

9.5.1 Source of Information

Contract documents and the instruction manual for Reinforcing Steel Bar Schedule Program BR00340.

9.5.2 Method of Calculation

The unit of measurement for reinforcing steel is determined from the nominal masses in Kilogram per metre and converted to tonnes.

Where a large quantity of reinforcing steel is required, the quantities should be calculated using the computer program and the computer printout should be included in the contract documents.

Two computer input sheets of the reinforcing steel schedule shall be prepared independently. A third party shall review both inputs and resolve any differences. The finalized input shall be entered in the computer. The output shall be checked and revised, if necessary, before the printout can be included with the contract documents.

Where the total number of bar marks for all reinforcing steel required is less than 20, the reinforcing steel schedule may be included with the contract drawings and the quantities may be calculated manually.

9.6 Documentation

Location and size of reinforcing steel shall be shown on contract drawings.

Specify coated reinforcing steel for areas of the structure exposed to road salt as given in Structural Manual.

Quantities for reinforcing steel and coated reinforcing steel form separate tender items. However, when the total quantity for both types of reinforcing steel for all work on the structure is less than 3 tonnes, then the steel quantity should be included with the applicable concrete placement item. The steel quantity will be documented on the drawings for the contractor's information only. In this case, OPSS 905 should be shown against the appropriate concrete placement item.

9.7 Documentation Accuracy

Quantities for reinforcing steel and coated reinforcing steel are to the nearest 0.1 tonne.

APPENDIX A-10

CONCRETE REMOVAL - FULL DEPTH - OPSS 510
REMOVAL OF STRUCTURE - OPSS 510

INDEX

10.1 General

These items should be used when a component or the structure is to be partially or completely replaced. The removal of concrete due to spalls, delaminations and high corrosion potential readings is normally not administered by these items because of the stringent jack hammer restrictions for this type of removal.

Where the new concrete face after removal is to be waterproofed, as is sometimes the case where old curbs and sidewalks are removed, an additional 25 mm (or 50 mm) depth of removal should be specified. All protruding reinforcing steel should be cut flush to the bottom of removal. The area should then be refaced with 25 mm of latex modified mortar or 50 mm of normal concrete depending on the depth of additional removal.

When removing concrete from thin deck slabs for the purpose of joint modification, the thickness of the concrete to remain at the bottom of the blockout should be at least 75 mm. Concrete less than 75 mm thick at the bottom of the blockout should be designated for removal as it would be difficult to keep this concrete intact during the jack hammering operation and this remaining concrete may not always be adequate for "formwork".

10.2 Tender Items

The following item descriptions and their corresponding units of measurement shall be selected for use according to their suitability when completing the list of tender items.

Description	Unit	Condition for Use
Removal of Structure	Lump Sum	- Complete removal of structure. - Removal of components other than concrete. - Partial or complete replacement of a concrete component where the dimensions of removal can be predetermined.
Concrete Removal - Full Depth	m^3	Partial replacement of a concrete component when the final dimensions of removal are to be determined during construction.

Where the total volume of removal for the bridge is less than 1 m^3, the removal of concrete may be administered under "Extra Work" procedures. Alternatively, this work may be included with the concrete placement item(s).

10.3 Specifications

Details of the work for removal of structure are covered by OPSS 510 and the special provisions.

10.4 Special Provisions

The designer should refer to the CDED manual for the applicable special provisions. Special provision 510S02 that restricts the size of removal equipment should be inserted when concrete is to be removed adjacent to concrete or other components that are to remain in place. A modified version of OPSS 510, contained in Appendix B, is to be used for the item "Concrete Removal - Full Depth".

A non-standard special provision is required to:

- identify components or portions of components to be removed under this item.
- include the work of delineating removal area by sawcutting.
- to include minor excavation and/or backfill with the lump sum items.
- clarify requirements for salvage of any materials.

10.5 Computation

10.5.1 Source of Information

The main sources of information are the original structure drawings and field notebooks.

10.5.2 Method of Calculation

Where payment for the work is by lump sum, the volume of concrete removal as well as quantities for other components should be calculated and given in the contract documents for the bidders' information, where practical.

Where measurement for payment is by m^3, the computation for concrete removal will be made from field measurements, concrete cores and dimensions, shown on original structure drawings.

10.6 Documentation

The contract drawings should indicate:

- components to be removed;
- extent of removal;
- location of sawcuts;
- treatment of existing reinforcing steel;
- extent of excavation required to facilitate removal;
- type of backfill;
- any utilities that may restrict the removal operation.

10.7 Documentation Accuracy

Quantities for concrete removal, by volume, are to the nearest 0.1 m^3.

APPENDIX B

DRAFT SPECIAL PROVISIONS

Special Provision No. 930D1 DRAFT January, 1989

Equipment

Subsection 930.06.08 Straight Edge of OPSS 930 is deleted and replaced by the following:

Where measurement for payment is by the volume method, the straight edges shall be 1.5 m and 3 m long and commercially made of metal.

Construction

Clause 930.07.02.04 of OPSS 930 is deleted and replaced with the following:

Concrete Removal

Environment

The Contractor shall protect the environment by controlling, collecting and disposing of all concrete and debris resulting from the concrete removal operation in a manner acceptable to the Ministry and in a manner that will prevent such material from entering any watercourse.

Access to Work Areas

The Contractor shall provide adequate access to facilitate any inspection or measurement of the work by the Engineer.

Typical locations and areas of repair are as shown on the contract drawings. The actual locations and extent of repairs will be as determined by the Engineer during the layout of the repair area.

Half-Cell Survey 1*

Concrete designated for removal shall include the areas where corrosion potential of the reinforcing steel is more negative than -0.35 volts for the following components:

Name of Structure(s)	Component(s)
2*	2*

The Ministry will carry out a half-cell survey to determine the corrosion potential of the reinforcing steel. For bridge decks, the half-cell survey will be carried out after removal of any asphalt and waterproofing, and, where applicable, after scarifying. The Contractor shall give the Engineer 96 hours notice before the anticipated start of concrete removal. Where the half-cell survey is delayed by weather or temperature restrictions, the Contractor may commence concrete removal in areas identified by the chain drag survey. When so notified by the Engineer, the Contractor shall sweep all debris from the concrete surface prior to the commencement of the half-cell survey. The Contractor shall expose the reinforcing steel at two widely separated locations for each portion of a component that is not continuous.

When concrete removal commences prior to the half-cell survey, the Contractor shall suspend the concrete removal operation for a period of 24 hours while the half-cell survey is being carried out. The Contractor shall schedule his work so as not to interfere with the half-cell survey operation.

Removal Procedure

The Contractor shall remove all loose and delaminated concrete and concrete designated for removal from areas as specified in the Contract and as demarcated by the Engineer prior to the work. The perimeter of the area to be removed shall be chipped to a neat vertical edge or sawn as specified in the Contract.

All concrete shall be removed using chipping and/or jackhammers. Jackhammers shall be used for the removal of concrete in front of and between the reinforcing bars. Only chipping hammers shall be used for the removal of concrete behind and within 25 mm of any reinforcing bar.

Concrete shall be removed in such a manner as to prevent damage to adjacent concrete and utilities that are to remain in place.

Reinforcing steel, prestressing tendons, shear connectors, structural steel or other components that are to remain in place shall not be damaged or loosened. The Contractor shall ensure that hammers do not come into contact with reinforcing bars in a manner which will cause debonding of bars in adjacent concrete areas not being repaired.

Where specified below, and unless otherwise noted herein; the Contractor shall remove concrete to a uniform depth of 25 mm behind the first layer of reinforcing steel. Concrete surrounding the second layer of reinforcing steel shall also be removed locally to provide a minimum clearance of 25 mm all around the reinforcing steel. All other concrete removal beyond the second layer of reinforcing steel shall be carried out only when directed by the Engineer. The average depth of concrete removal for each component is specified in the Contract.

Concrete removal shall extend below the reinforcing steel from within the following areas.

a) The entire area of spalls and delaminations as demarcated by the Engineer.

b) The areas of concrete components where corrosion potential of the reinforcing steel is more negative than -0.35 volts. (This applies to components where the Contract specifies concrete removal based on half-cell survey results.)*1

c) All reinforcing steel exposed due to scaled concrete, within the boundaries of demarcation lines placed by the Engineer.

If existing reinforcing steel is not exposed during concrete removal of scaled concrete and sound concrete does not have to be moved in this area for other reasons, existing concrete shall not be removed more than that required to expose the surface of sound concrete except where the Contract specifies a minimum depth of removal for scaled concrete.

Where reinforcing bars have been exposed, concrete removal shall extend along the bars until they are free from heavy rust. Concrete covering bars at the edge of the repair area shall be sounded by the Engineer for local delaminations before removal operations are completed.

Where the area of concrete removal with exposed reinforcing steel exceeds 2 m^2, the reinforcing steel shall be retied at every second intersection point and shall be supported to maintain the steel mat in its original location. Supports conforming to OPSS 905 shall be placed as required and tied securely to the reinforcing steel.

Disposal of Removed Materials

As part of the removal operation the Contractor shall supply all necessary equipment and operators to load, haul and dispose of the material resulting from the removal of concrete including arrangements for the disposition of the material at locations outside the right-of-way.

Measurement for Payment

Subsection 930.09.01 of OPSS 930 is deleted and replaced with the following:

Concrete Removal - Deck Surface
Concrete Removal - Structure
Concrete Removal - Deck Soffit

The measurement for payment will be of the volume of concrete removed in cubic metres.

The volume will be calculated by multiplying each area of removal by that area's average depth. Depths will be taken on a grid system to best describe the profile at the particular area. The Contractor and the Engineer will take the measurements after concrete removal is completed by placing a straight edge across the removal area and measuring the depth from the straight edge to the concrete. The total volume will be calculated to the nearest 0.01 cubic metres.

Measurement will not be made of concrete removed locally from behind the second layer of reinforcing steel.

Basis of Payment

Subsection 930.10.01 of OPSS 930 is deleted and replaced with the following:

Removal of Concrete
Concrete Removal - Deck Surface
Concrete Removal - Structure
Concrete Removal - Deck Soffit

Payment at the contract price for the above tender item(s) shall be full compensation for all labour, equipment and materials required to do the work including the provision of access to work areas when there is no separate tender item.

Note to Designer

1* Where there are no components that will have removal of concrete based on corrosion potential readings, delete all references and sections that apply to half-cell survey and corrosion potential readings.

2* Indicate which structures and their components that will have concrete removal based on half-cell survey results.

WARRANT: Always with these tender item(s) when concrete removal is to conform to OPSS 930.

Special Provision No. 930D4 **DRAFT** **88 11 14**

Scope of Work

The Contractor shall supply a three man work unit to remove the concrete from the following components:

Name of Structure	Components
*	*

Equipment

Section 930.06 of OPSS 930 is amended by the addition of the following:

Air Compressor - Removal of Concrete

For the purposes of removal of concrete measured on a crew hour basis, the air compressor(s) shall supply a minimum of 620 KPa within 3 m of the hammer. As a guide, the minimum pressure can be achieved using equipment as detailed in Table 1.

TABLE 1

Type of Hammer	Minimum Air Volume per hammer
Chipping	1.0 m^3/min.
Jack	1.2 m^3/min.

Deck Preparation

Subsection 930.07.02 of OPSS 930 is amended by the addition of the following:

Three Man Work Unit

The Contractor shall use a three man work unit to remove existing concrete from areas of the components designated for repair and collect and place the removed material in a suitable location adjacent to the work area to faciliate loading, hauling and disposal.

The work unit shall consist of three labourers, air compressor(s) and sufficient chipping hammers and/or jackhammers to ensure that three such hammers in good repair are available at all times for the efficient removal of concrete and the Contractor shall supply all other equipment required to do the work.

Measurement for Payment

Subsection 930.09.01 of OPSS 930 are deleted and replaced with the following:

The measurement for removal of concrete will be based on the number of crew hours (three man) that the work unit is in effective operation while removing concrete and placing the removed material in a location immediately adjacent to the work area to facilitate loading, hauling and disposal of removed concrete and debris.

Note to Designer:

* - Indicate the structures and their components to which item applies to.

Warrant: With this tender item when measurement for payment is by crew hour (three man).

Special Provision No. 930D5 **DRAFT** **88 11 14**

Sb Scope of Work

The Contractor shall supply a five man work unit to remove the concrete from the following components:

Name of Structure	Components
*	*

Equipment

Section 930.06 of OPSS 930 is amended by the addition of the following:

Air Compressor - Removal of Concrete

For the purposes of removal of concrete measured on a crew hour basis, the air compressor(s) shall supply a minimum of 620 KPa within 3 m of the hammer. As a guide, the minimum pressure can be achieved using equipment as detailed in Table 1.

TABLE 1

Type of Hammer	Minimum Air Volume per hammer
Chipping	1.0 m^3/min.
Jack	1.2 m^3/min.

Deck Preparation

Subsection 930.07.02 of OPSS 930 is amended by the addition of the following:

Five Man Work Unit

The Contractor shall use a five man work unit to remove existing concrete from areas of the components designated for repair and collect and place the removed material in a suitable location adjacent to the work area to facilitate loading, hauling and disposal.

The work unit shall consist of five labourers, air compressor(s) and sufficient chipping hammers and/or jackhammers to ensure that four such hammers in good repair are available at all times for the efficient removal of concrete and the Contractor shall supply all other equipment required to do the work.

Measurement for Payment

Subsection 930.09.01 of OPSS 930 are deleted and replaced with the following:

The measurement for removal of concrete will be based on the number of crew hours (five man) that the work unit is in effective operation while removing concrete and placing the removed material in a location immediately adjacent to the work area to facilitate loading, hauling and disposal of removed concrete and debris.

Note to Designer:

* - Indicate the structures and their components to which this item applies.

Warrant: With this tender item when measurement for payment is by crew hour (five man).

RENTAL OF AIR HAMMERS (Operated) - Item No.

Special Provision No. 930D6	**DRAFT**	**88 11 15**

Clause 930.07.02.05 of OPSS 930 is deleted and replaced with the following:

When the Engineer determines that it is necessary to increase the size of the work unit for the crew hour removal method, the Contractor shall provide additional hammers (operated) and when necessary increase the air volume output to accommodate the additional equipment.

Subsection 930.10.02 of OPSS 930 is amended by the addition of the following paragraph:

No additional payment will be made for any increase in the size of the compressor needed to increase the air supply for the operation of such additional hammers.

Warrant: Always with this tender item.

Special Provision No. 510S02 Modified March 1988

Amendment to OPSS 510

OPSS 510 is amended by the addition of the following:

510.04 Submission and Design Requirements

510.04.01 Sawing Proposal

When it is intended by the contractor to remove concrete deck slabs or to partially remove other structural components by use of sawing equipment he shall submit three complete sets of drawings to the Authority, three weeks prior to the intended commencement of the removal operation. The drawings shall indicate the depth and location of all saw cuts including the method to be used to prevent any contact with components that are to remain in place.

Work affected by these proposals shall not proceed until the Contractor receives a copy of these proposals, stamped with the words "Permission to Construct".

510.04.02 Rig-Mounted Breakers

The contractor shall submit to the Authority prior to the commencement of the removal operation, the manufacturer's specifications for the Rig-Mounted Breaker(s) he intends to use. The Rig-Mounted Breaker(s) shall not be put to work until the Contractor receives written approval from the Authority.

510.06 Equipment

510.06.01 Air Hammers

Chipping hammers shall be 7.0 kg maximum.

Jack hammers shall be 14.0 kg maximum.

Breakers shall be 28.0 kg maximum.

510.06.02 Rig-Mounted Breakers

Rig-Mounted Breakers shall be fitted with a moil point only and produce a maximum energy of 600 Joules per blow.

Subsection 510.07.02 Demolition, of OPSS 510, is amended by the addition of the following:

510.07.02.01 General

The work shall include, where indicated in the contract, the cutting and removal of reinforcing steel and other components embedded or anchored in the concrete, and the maintenance, cutting and bending, of existing reinforcing steel which is to remain. The cutting and bending of existing reinforcing steel shall conform to OPSS 905.

Reinforcing steel, shear connectors, structural steel or other components that are to remain in place shall not be damaged or loosened. The Contractor shall exercise care during removal operations to ensure that hammers do not come in contact with reinforcing steel bars in a manner which will cause debonding of bars in adjacent concrete areas not being repaired.

510.07.02.02 Operational Constraints

The use of breakers will not be permitted for the removal of concrete located less than 100 mm from concrete to remain in place or for the removal of concrete for joint installation on the bridge deck.

All concrete being removed within 100 mm of concrete to remain in place, concrete being removed for joint installation on bridge decks, and concrete being removed from above concrete or steel girders or diaphragms integral with the deck, shall be removed using chipping hammers and/or jackhammers. Jackhammers shall be used for the removal of concrete above and between the reinforcing steel. Only chipping hammers shall be used for the removal of concrete behind and within 25 mm of any reinforcing steel that are to remain and that are located within 100 mm of concrete to remain in place.

The use of Rig-Mounted Breakers will not be permitted for the removal of concrete located less than 300 mm from concrete to remain in place.

Rig-Mounted Breakers will not be permitted for removal of deck slabs except for concrete deck slabs that are supported by steel beams or girders.

The use of a Rig-Mounted Breaker will not be permitted in locations less than 100 mm from the edge of the flanges of steel beams, girders or diaphragms, for removal of concrete in deck slabs over steel girders.

Sawing of concrete for the purposes of concrete removal will be permitted subject to conformance with subsection 510.04.01.

Measurement For Payment

Section 510.09 of OPSS 510 is amended by the addition of the following subsection.

510.09.13 Concrete Removal - Full Depth

The measurement for payment will be of the volume of concrete removed in cubic metres.

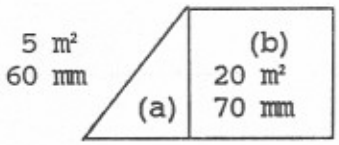
WARRANT: With this tender item upon recommendation of the Regional Structural Section.

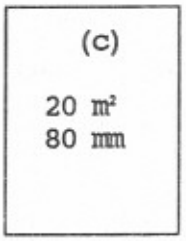
APPENDIX C

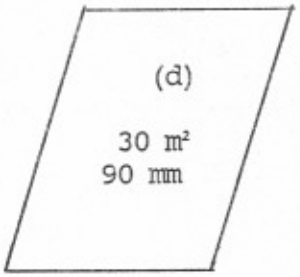
SAMPLE CALCULATION FOR AVERAGE DEPTH OF REMOVAL DURING CONSTRUCTION

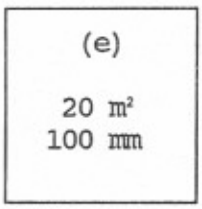
A) Delaminations or concrete with half-cell readings less than -0.35 volts.

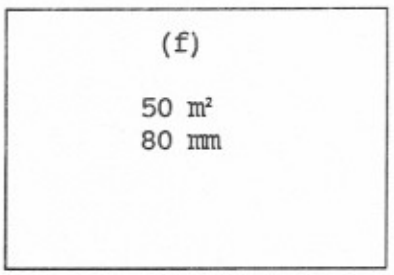
Notes: 1. Areas determined from abrasive blast cleaning calculations.
2. Depth is the average for each individual area.



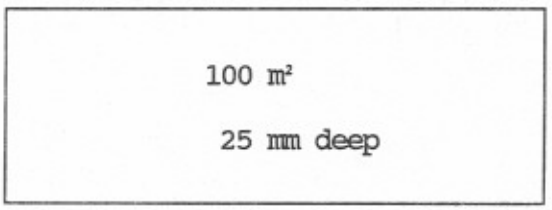








B) Scaled Concrete Removal



Area "A"	a = 5 m²	Volume "A"	a = (5X.06)÷2 = 0.15 m^3
	b = 20 m²		b = 20 X 0.07 = 1.40 m^3
	c = 20 m²		c = 20 X 0.08 = 1.60 m^3
	d = 30 m²		d = 30 X 0.09 = 2.70 m^3
	e = 20 m²		e = 20 X 0.10 = 2.00 m^3
	f = 50 m²		f = 50 X 0.08 = 4.00 m^3
Area "A" Total	=145 m²	Volume "A" Total	=11.85 m^3

Weighted average depth of removal for "A" = 11.85 ÷ 145 = 81.7 mm.

Volume "B" = 100 X 0.025 = 2.5 m^3

"A" + "B" = Total Volume of Removal = 11.85 + 2.50 = 14.35 m^3

APPENDIX D

CONCRETE REMOVAL PRODUCTION RATES

Structure Name	Site No.	Component	Removal Quantity	Number of Crew Hours	Size of Work Unit	Production Rate per Man Hour
Sydenham River	14-232	Deck	13.4 m^3	107	5 man	0.025 m^3
		Substructure	13.5 m^3	348	3 man	0.013 m^3
Sydenham River	14-233	Deck	18.7 m^3	156	5 man	0.024 m^3
		Substructure	5.5 m^3	243	3 man	0.008 m^3
Hwy. 73/401 U'pass	19-304	Deck	29.88 m^3	132	5 man	0.045 m^3
		Substructure	6.12 m^3	118.8	3 man	0.017 m^3
Dorchester Rd.	19-303	Deck	7.96 m^3	35.5	5 man	0.045 m^3
		Substructure	3.74 m^3	102.3	3 man	0.012 m^3
Blind River	38S-258	Deck	2.8 m^3	45.5	5 man	0.012 m^3
Prairie Bee River	46N-219	Deck	1.9 m^3	17	5 man	0.022 m^3
Jackfish River	48C-008	Deck	1.18 m^3	19.5	5 man	0.012 m^3

Observations and Recommendations

1. Concrete removal was based on chain drag and hammer sounding.

2. The production rates were highly variable from structure to structure due to variation in concrete quality and work unit efficiency.

3. The production rate for decks is two to three times the production rate for substructures.

4. The designer uses a production rate of 0.08 m^3 per crew hour for decks. This rate may be suitable if concrete is of good quality. If concrete is of poor quality (i.e. disintegrating or low compressive strength) then a production rate of 0.125 m^3 per crew hour should be used to determine the crew hour quantities.

Observations and Recommendations (cont.)

5. The designer uses a production rate of 0.05 m^3 per crew hour for soffit and substructure removals. This appears to be too high and should be reduced to 0.04 m^3 per crew hour.

6. The production rates recommended in comments (4) and (5) could be improved with more data. However, it is expected that very few structures will have concrete removal administered by the crew hour method in the future. Furthermore, as the production rate used by design is an average, the actual production rate for any given structure will still be highly variable.