

Sample proposal for the use of Lok-Test on a project

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PART I PROPOSAL

RATIONALE

- o For each month the construction schedule can be shortened, reductions in interest and overhead, and increases in rent can produce savings to the owner of the order of \$233,000.
 - o A significant acceleration in the cast-in-place concreting programme would make an over-all acceleration possible.
 - o Concretes and testing methods which make an accelerated programme practical are available in Toronto.
 - o It has been assumed that if any part of the suggested programme is adopted, there will be competent technological input into the contract documents and into the quality control of concrete during construction.
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TECHNICAL PROPOSAL

- o Allow form removal and re-shoring at 75 per cent of f'_c .
 - o Provide concrete mixes to meet any form removal time, down to 24 hours after casting, that allows a faster forming and placing schedule.
 - o Accelerate form removal and re-shoring of all slabs to match the fastest practical schedule.
 - o Design concrete mixes for all vertical members to meet f'_c at 91 days.
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ACTIONS REQUIRED AFTER ACCEPTANCE
OF AN ACCELERATED PROGRAMME CONCEPT

- o Documents for the concrete supply and forming and placing contracts would need amendments. We can help to provide these.
 - o The forming and placing contractor is the key to an accelerated programme and has to be motivated. This needs discussion by the construction team.
 - o Appropriate quality control of the concreting process will be required.
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COSTS TO OWNER

	<u>Sub-Structure</u>	<u>Superstructure</u>	
o Additional costs of accelerated concrete mixes	N.A.	\$151,606	
o Saving on concretes meeting 91 day test requirement	\$ 39,000	\$ 37,500	
o Saving on winter heating costs	N.A.		
Net cost of additional cost of concrete	<u>\$ 39,000</u>	<u>\$114,106</u>	
Net cost of additional cost of concrete - Sub-structure and Superstructure		\$ 75,106	
o Cost of in-place testing with resident inspector	N.A.	\$ 38,600	
o Cost of standard testing	\$ 14,000	\$ 15,000	
Net additional cost of in-place testing resident inspector.	<u>N.A.</u>	<u>\$ 23,600</u>	
Net additional cost to owner.		<u>\$ 98,706</u>	A

SAVINGS TO OWNER

o	Reduction in financing costs.		
	1 month acceleration	\$187,500 - \$190,000 (say \$188,000)	
	2 month acceleration	\$375,000	
o	Earlier Rental per month	\$ 25,000	
o	Owner's overhead per month	\$ 20,000	
o	Credits from contractor.	Not considered at this time.	
	Savings to owner assuming a one month acceleration	<u>\$233,000</u>	B
	Net savings to owner B - A	<u>\$137,894</u>	

PART 11 APPENDIX

RATIONALE

With savings of the order of those quoted, plus other savings that would accrue to both the owner and the construction team in the form of reduced overhead, it seems to us that a policy decision to accelerate the programme is justified.

It also seems justifiable to offer financial incentives to the formwork industry to encourage their interest in speed.

It should be remembered that the maximum benefit will only be realized if all other construction activities are re-scheduled to the accelerated programme.

On a number of major projects in the Toronto area we have been involved in the design and use of a wide range of special mixes. These range from mixes which allow the removal of forms from floor slabs at 24 hours after casting, to 9000 psi cast-in-place concrete, and the use of 56 and 91 days for determining f'_c in order to obtain technical or economic benefits. Our experience shows that with the right specification, pre-construction meetings, and effective supervision and testing, the local ready-mixed concrete industry can deliver these special concretes with consistency and reliability.

We have also used these special mixes with the agreement of the building officials having jurisdiction. Our policy is to seek this agreement at the start of a project.

In-place testing methods approved by ASTM and recommended by CSA would be used. We would mainly use LOK-TEST, which gives a statistically valid determination of the strength of the actual concrete in the structure. Other advanced methods would be used as and when appropriate.

TECHNICAL PROPOSAL

The criteria for the removal of forms has to be decided by the Engineer. The value quoted has been used previously by this Engineer. These criteria would be established finally after the accelerated programme is better defined and has been reviewed with the Engineer.

Concrete mixes can be formulated to meet any form removal programme. Depending on the formwork sub-contractor's programme, the mixes can be designed to get strengths which match this programme. If, for example, the programme calls for a five-day week with form stripping at one day, concrete placed Monday to Thursday could be a mix suitable for one day stripping. On Friday, however, a mix suitable for three day stripping would be used since it is cheaper and there would be no advantage in gaining strength faster.

We have used this approach on a number of projects and some of these have been reported in the technical literature ^{1,2}.

Control of formwork stripping would be achieved by the use of in-place testing.

The proposed system provides about ten times as many tests as are made to meet standard cylinder testing specifications. All tests are physical tests in-place (i.e. the test is on the concrete in the element of the structure being stripped). A statistically valid result is therefore obtained and the test and the results are carried out on site, the apparatus being portable.

A control system is exercised which involves the following steps:

1. Testing on site.
2. Calculation of results on site.
3. Checking arithmetic and results with an authorized person at head office by telephone. This takes only two or three minutes as all authorized personnel have a suitably programmed calculator on their desk.
4. Confirmation in writing to the authorized representative giving
 - a) Mean strength, standard deviation, and minimum strength.
 - b) Levels and limits of the part of the structure tested.
 - c) Whether the area tested meets or does not meet the Engineer's requirements for stripping.
5. A signature of the authorized site representative on the standard form we use to confirm receipt of our data is obtained for our records.

For a typical pour the above procedure takes approximately 30 minutes. If results fail to meet stripping criteria, testing is stopped as soon as this is obvious (usually after 5 tests) and re-testing is scheduled for later. Enough pull-out bolts are installed to allow this to be done.

For vertical elements where rapid strength gain is irrelevant, we would propose to use a different approach.

The design strength of the columns is not required until long after they are cast. We would therefore propose to use a mix proportioned to meet design requirements 91 days after casting. Again, we have done this in Toronto on a number of major projects and the results have been reported in the technical literature ^{3,4,5}.

The type of mix used would contain supplementary cementing material to ensure good strength gain at ages later than 28 days.

COSTS TO OWNER

Concrete costs are difficult to estimate because market factors at the time of bidding have a major effect on prices.

The prices we have used are based on our best estimate of market prices.

Acceleration

The following are the premiums assumed to apply compared to the cost of normal 30 MPa concrete:

Concrete suitable for stripping at	Premium \$/yd. ³
1 day (18 hours)	6.75
2 days (42 hours)	5.06
3 days (66 hours)	3.94

91 Day Strength

Reduction assumed for determining f'_c at 91 days instead of 28 days is \$5/yd.³. On one recent downtown project the actual reduction was \$6.50/yd.³ but the market conditions prevailing at the time of tender may alter this. We have therefore used a conservative value.

Quantities

	Horizontal Elements (Slabs, Beams)	Vertical Elements (Walls, Columns)
Sub-structure *	26,800	7,800
Superstructure	24,500	7,500

* Excludes footings and slab on grade.

Concrete CostsAccelerationSub-structure

Although acceleration of sub-structure construction can be achieved in some instances, there is usually resistance to this concept on the part of the forming contractors. We have therefore discounted acceleration of the sub-structure in this study.

Superstructure

Assume 80 per cent of concrete placed Monday to Thursday and stripped at 1 day, and 20 per cent placed on Friday and stripped at 3 days:

0.80 x 24,500 x \$6.75	\$132,300
0.20 x 24,500 x \$3.94	<u>\$ 19,306</u>
TOTAL:	<u>\$151,606</u>

Saving on 91 day concrete:

15,300 x \$5	\$ 76,500
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Concrete testing costs are based on the following assumptions:

Total yardage - 66,600.

Routine testing of cylinders including some field cured cylinders would require approximately 2,300 cylinders.

Assuming the use of a good quality testing laboratory, a unit price of \$12.50 per cylinder is a reasonable expectation. Adding in costs of air tests and some miscellaneous testing, the routine testing should cost approximately \$29,000.

In-place testing systems carried out by laboratories on a visiting basis cost approximately \$1.00 per yd.³ of concrete. The normal cost of testing all horizontal elements of the superstructure for early stripping would therefore be \$24,500.

If the present schedule is accelerated for the superstructure because the volume of concrete is large, we believe your interests would best be served by a resident technician.

We also believe that if an accelerated programme and a resident technician are agreed to, it may be possible to eliminate about 90 per cent of the routine testing by cylinders for horizontal elements of the superstructure. We have already obtained permission to do this on another project from the authority having jurisdiction, and subject to your approval, discussions with the authorities on your behalf would be part of our consulting services.

Until we can meet with the contractor, we cannot discuss schedules, but have assumed a 20 week period for an accelerated superstructure.

Providing a resident inspector for 20 weeks at
2 x payroll and allowing 20 per cent overtime would cost:

20 x 40 hours x 1.2 x \$20.00	\$19,200
LOK-TEST bolts 4,000 x \$3.30	\$13,200

Cylinder testing (less 90 per
cent of flat areas)

$$\left(\frac{7,500}{32,000} + 0.10 \frac{24,500}{32,000} \right) 1100 \times \$12.50 =$$

$$(0.23 + 0.08) 13,750 = \$ 4,200$$

Contingency:	<u>\$ 2,000</u>
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Total cost of testing:	\$38,600
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Cost of normal testing (32,000 yd. ³)	<u>\$15,000</u>
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Premium:	<u>\$23,600</u>
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SAVINGS TO OWNERFinancing

Assuming a maximum investment during frame construction of \$30,000,000, and taking the two presently projected programmes for the structural frame, ie. 10 months fastest and 12 months optimum financing costs would be as follows:

10 month programme

10 month cost		
$\frac{10}{12} \times \frac{1}{2} \times 30 \times 10^6 \times 15\%$		\$1,875,000

9 month cost		\$1,685,000
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Saving		\$ 190,000
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8 month cost		\$1,500,000
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Saving		\$ 375,000
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12 month programme

12 month cost		\$2,250,000
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11 month cost		\$2,062,500
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Saving		\$ 187,500
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10 month cost		\$1,875,000
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Saving		\$ 375,000
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Rental

This is difficult to quantify so we have adopted a conservative approach assuming that only \$2,000,000 of the \$14,000,000 total rent is accelerated per month of acceleration in the construction programme.

The saving is therefore

$$\$2,000,000 \times 15\% \times \frac{1}{12} = \$25,000/\text{month}.$$

Overhead

We understand that the saving per month will be approximately \$20,000.

Credits from Contractors

In dealing with this aspect, we have, for the moment, assumed that the owner will receive no credits. In principle, each party to an accelerated programme requires some incentive. We feel therefore, that it is up to the owner to decide how to handle this aspect of the contract negotiations.