Ministry of Transportation

Bridge Office

Report BO-99-04

Palladium Drive Over Hwy 417

# Performance of Integral Abutment Bridges

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# Performance of Integral Abutment Bridges

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## INTRODUCTION

Although many Integral Abutment Bridges have been built in the U.S.A. and Canada in the last three decades, considerable interest has been generated in the design, construction, performance and behaviour of such bridges in the last 10 years (1,2,3,4,5,8,9). The first Integral Abutment Bridges in the Province of Ontario were designed and built in the1960's. It is only in 1990's that the Province increased its efforts in the design and construction of such bridges. The reasons for not attempting more designs and continuing with this kind of bridge are not documented. This could be attributed to the improved quality of expansion joint systems, the absence of any rational design methods and guidelines or the absence of any performance evaluation of such structures. It is with this in mind that The Ministry of Transportation of Ontario issued a report in 1993 (6) in an attempt to establish the general guidelines for the planning, design and construction of such structures in the Province. Since the publication of this report more than 100 new structures have been built and their performance is monitored visually. Based on this experience and the performance of these structures, the Ministry published an updated report in 1996 (7) and established a monitoring process for the performance of these structures. If it is desired to increase the awareness and confidence in the design and construction of these bridges among the designers, it is imperative that a systematic performance study be carried out and the results of this study are documented.

## MONITORING OF EXISTING STRUCTURES

In order to increase the designer confidence in Integral Abutment Bridges, a periodic and systematic visual inspection of structures built in the Province is carried out to record the performance. A visual inspection of all bridges is carried out as a part of the biennial inspection program. In addition, a more specialised inspection of selected structures is carried out twice in a year, during the winter and summer, following a long stretch of extreme cold and warm temperatures, and any signs of distress or unusual behaviour are recorded. In the selection of the bridges for monitoring, consideration is given to the total length of the structure, type of deck, type of traffic, location, and any unusual characteristics such as skew, curvature or grade.

During the inspection, special attention is paid to the following:

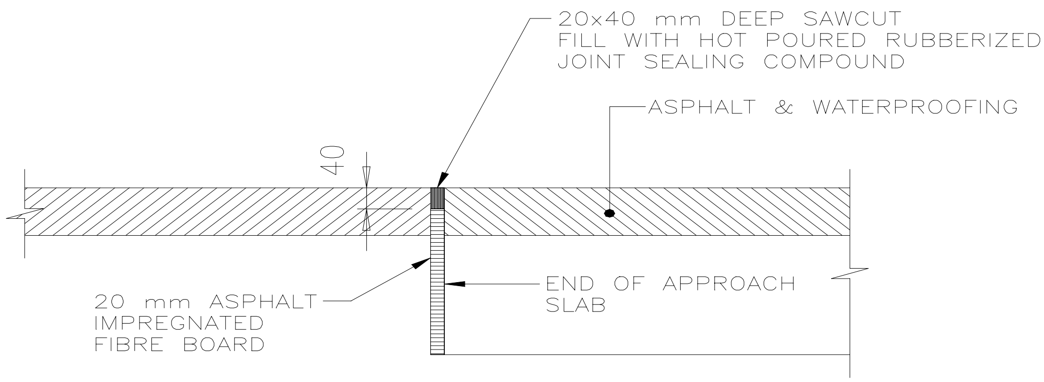
- condition of isolation joints at the end of approach slab
- cracks in the abutment wall
- cracks in the wingwalls
- cracks in the barrier walls at the end of deck
- cracks in the deck, and sign of distress in the girders.
- wet areas around the ballast walls and bearing seats.

### Observations:

The results of our observations are very encouraging. The structures are performing well and there is very little sign of deterioration or distress in any of the observed structures.
The following are a few of the observations worth mentioning.

Isolation joints:

The isolation joint detail as shown in Fig 1 works well where the total length of the structure is less than 75m for steel structure and 100m for concrete structure. The gap widens in the winter and the edges of asphalt pavement appear to separate from the sealing compound, see Fig 2.




EXPANSION JOINT AT END OF APPROACH SLAB

MAX. MOVEMENT 25 mm

FIG. 1

Fig 2

This gap, however, closes again in summer and does not result in any loss of riding quality. It is anticipated that after a few years of repeated movements it may become necessary to replace the rubberised joint sealing compound and carry out minor repairs to the edges of asphalt pavement.

In some cases where the total length of the structure exceeds the above limits, there is evidence of a wider gap at the joint location and distinct separation of sealant during the winter months as shown in Fig 3.

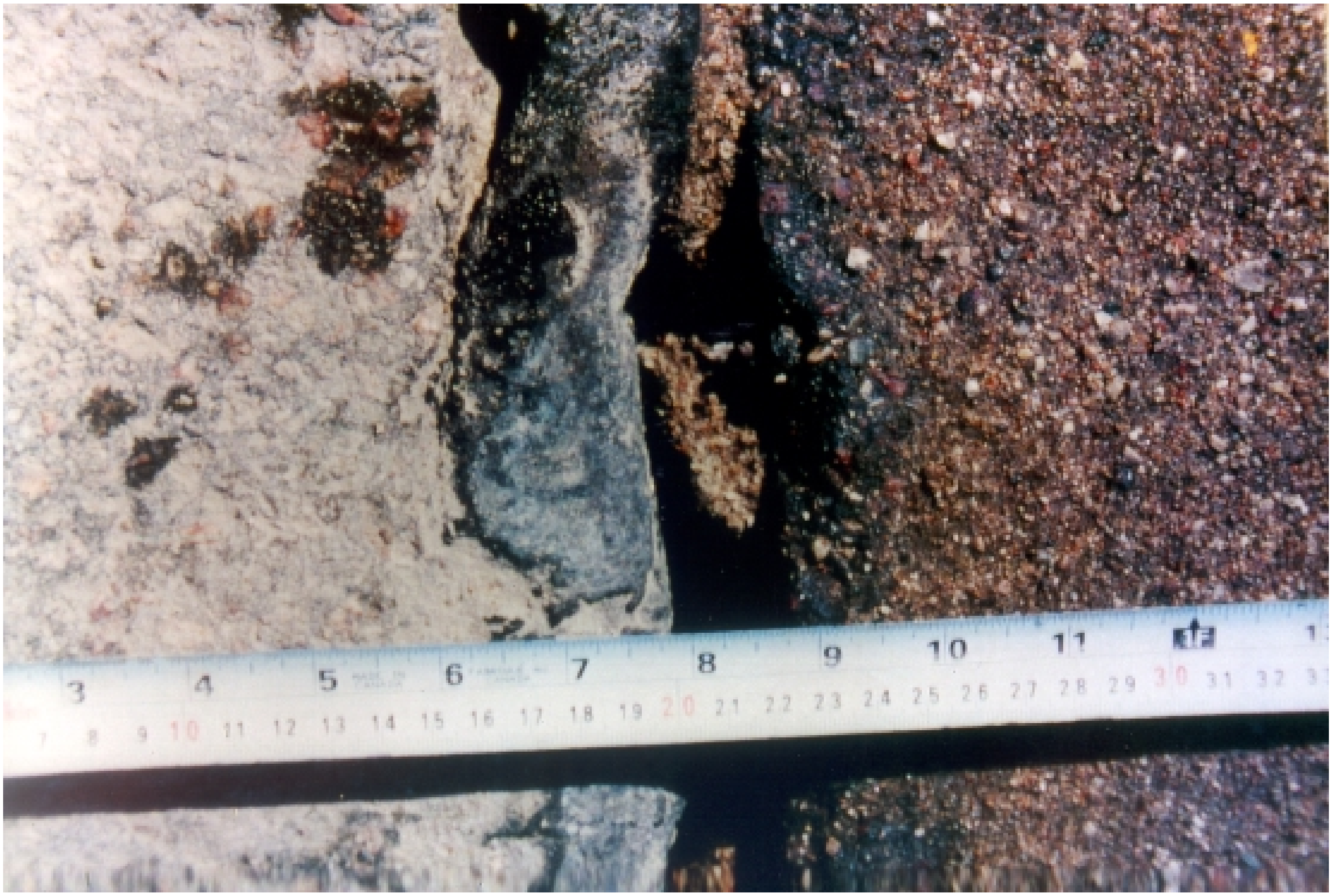
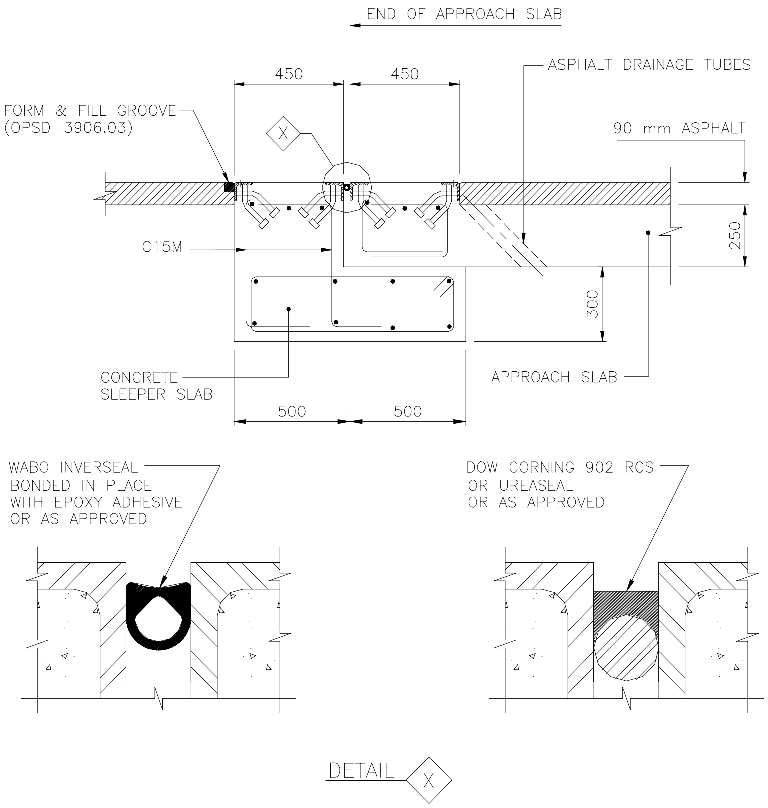

3 4 5 6 7 8 9 10 11
29 30 31 32
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

Fig 3

It is felt that this may cause a reduced quality of ride and may require more frequent repair. As a result, MTO has developed a more elaborate movement joint detail for bridges where the total length is more than 75m for the steel structures and 100m for the concrete structures as shown in Fig 4.




EXPANSION JOINT AT END OF APPROACH SLAB
FOR CONCRETE BRIDGES GREATER THAN 100 m IN LENGTH
AND STEEL BRIDGES GREATER THAN 75 m IN LENGTH
FIG. 4

Construction Precautions and Maintenance of the Joints:

The quality control during the construction of isolation joints and the preparation of the sub-base, greatly influences the durability and effectiveness of the joint. A well made joint should be placed on a well compacted sub-base between straight sawn cut edges as shown in Fig 5. A carelessly made joint and deficient compaction of the sub-base in the vicinity of the joint, as shown in Fig 6, may result in early deterioration of the pavement and may need more frequent maintenance. It is recognised that even a well made joint will, deteriorate in time and would require maintenance (Fig 7,8,9). The Maintenance crews should be fully aware of the need and function of these rather simple looking joints. In some cases the lack of awareness has resulted in partial or complete elimination of the joint during a maintenance operation (Fig 10).

Fig 5

Fig 6

Fig 7

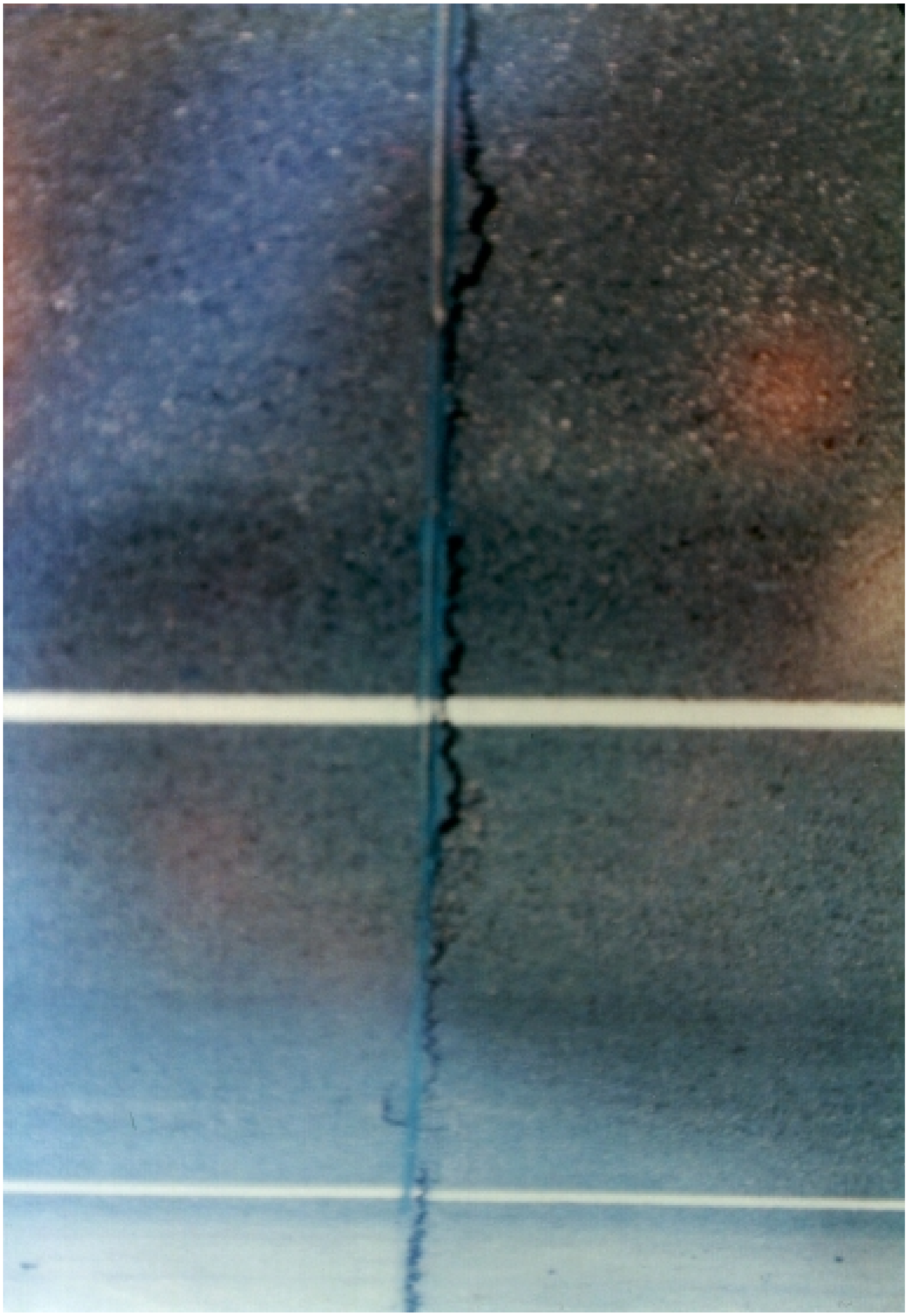


Fig 8

Fig 9

Fig 10

Barrier Walls:

There is evidence of cracking in barrier walls just above the abutments. The most likely cause of this is the tension from negative bending moment at the supports (Fig 11). These cracks are not desirable as they may lead to durability problems due to ingress of salt and water, resulting in rapid deterioration of the barrier walls. It is suggested that the barrier wall should be provided with additional reinforcement at this location and the length of wingwall and height of the abutments should be minimised to reduce the negative bending moment. Alternatively an expansion joint may be provided in the barrier wall at this location.

Fig 11

Continuity of Curbs:

In many cases the edges and corners of the curbs have been damaged at the abutment locations as shown in Fig 12. This damage appears to have resulted from a gap that is too small to accommodate movements, or the complete absence of a joint. This could be avoided by providing an expansion joint in the curbs at this location.

Fig 12

Bearing Pedestals:

In fully integral bridges the purpose of the bearing seat pedestals is to minimise the eccentricity of loads transferred to the piles and to provide for the anticipated girder end rotations without causing damage or causing built-in stresses. In many bridges, a diagonal hairline crack, starting at the tips of lower flange of the girder, is apparent as shown in Fig 13. These cracks are not significant and not likely to cause a major durability concern. The cracks appear to have been caused by a stress concentration and load transfer to the concrete in front of the pedestals. The thickness and hardness of the bearing pad plays a significant role in load transfer. A thin stiff, bearing should be used to minimise deformation due to load transfer. In the past, MTO has used 15-20 mm thick rubber or elastomeric pads with 50+/-5 Duro-hardness, but this practice is currently being reviewed.
It is suggested that the height of the pedestals and space in front should be sufficient to place adequate reinforcement in this area.

Fig 13

Corrosion of Steel Girder Ends:

The condensation due to the difference in temperature between the steel girder ends and adjoining concrete or other atmospheric reason causes rust stains at the face of the abutment as shown in Fig 14,15. It is suggested that girder ends within 500mm from the face of the abutment should be coated to avoid this problem.

Drainage of box girders:

Holes should be provided at the lowest points at the ends of box girders to provide for drainage. They should be carefully detailed on the drawings to ensure that they are not covered in the end diaphragms.

Fig 14

Fig 15

Conclusions:

The Ministry of Transportation of Ontario has gained considerable experience in the design, construction and performance of Integral Abutment Bridges in the last few years. Our experience to date has been very positive and it is expected that more such bridges will be designed and built in the future. Bridges with less than 100m in length have performed well and appear to be ideally suited for this design. Data on bridges in Ontario, with lengths more than 100m, is limited, but with the suggested modifications to the control joint details, these bridges show the potential to also perform well in the long term.

Future Directions:

It is intended that the Ministry will continue to monitor the performance of these bridges and based on the results of this monitoring it will revise its guidelines and policies to limit or extend their application. The Ministry intends to look into following:

Extend the limit on total length of the structures.
Include post-tensioned deck type structures.
Explore the use of pipe and wood piles
Use of Semi-integral arrangements where integral design is not feasible.
Use of more rigid foundations for smaller spans.

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