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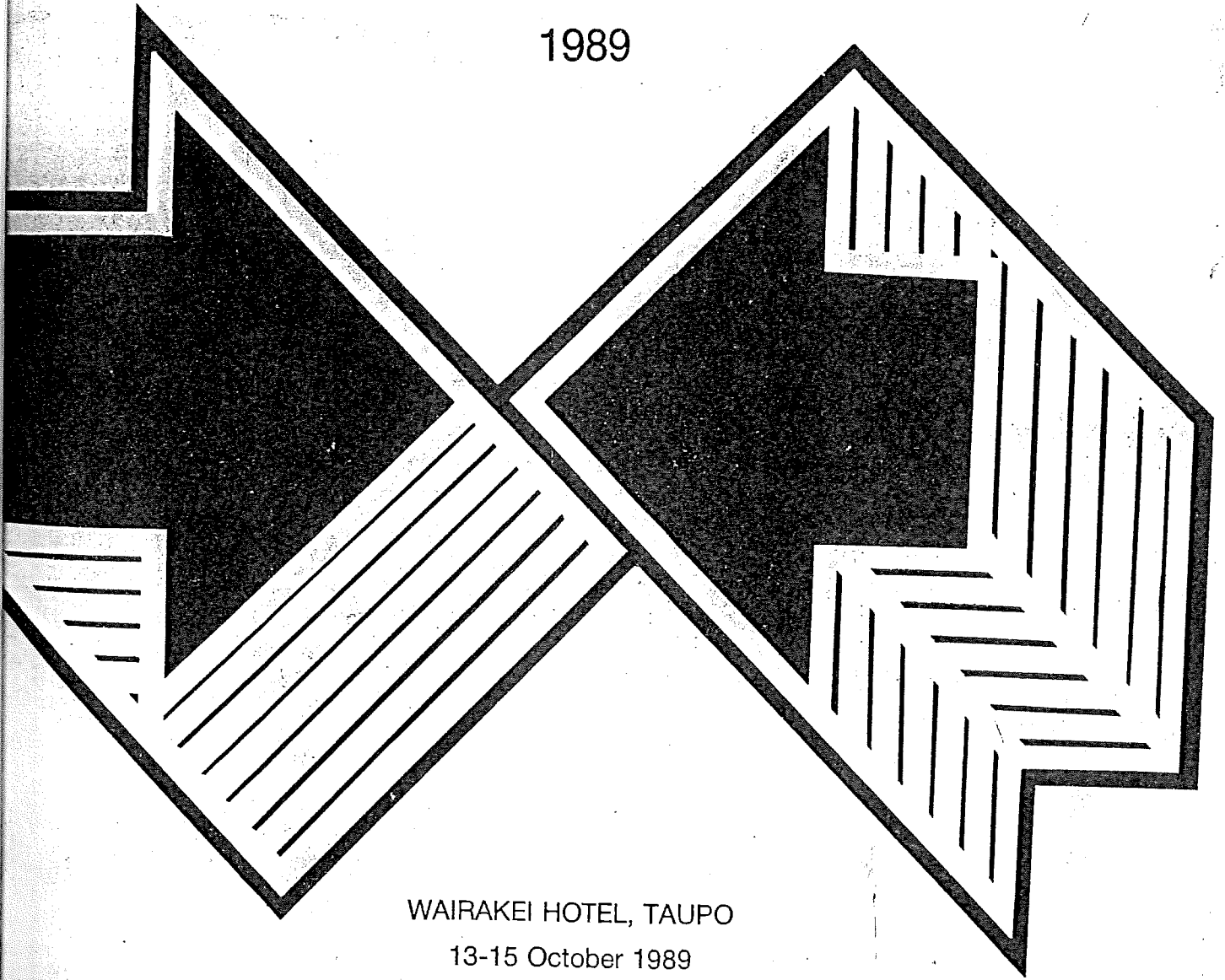
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# MOVABLE CONCRETE BARRIERS FOR THE AUCKLAND HARBOUR BRIDGE

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## 1. Introduction

The intent of this paper is to report on the progress for the planned use of a movable concrete median barrier for the Auckland Harbour Bridge. A full technical paper on all aspects of the project's design will be presented on completion of the project.

It is not often that concrete is used in a dynamic situation and it is the basic simplicity of the idea that makes the concept a workable, viable solution to solving the problem of head on collisions on the Auckland Harbour Bridge.

## 2. Problem Definition

The National Roads Board (which is to be incorporated into Transit New Zealand), has been committed to a substantial programme of median barrier construction on the motorway system.

The 24 hour surveillance on the Auckland Harbour Bridge means that very complete information is available from the Ministry of Transport on all accidents, particularly injury and fatal accidents. In the period 1984 to 1988 there have been 22 accidents involving head on collisions with 10 fatalities.

The harbour bridge obviously is the only missing link in providing barrier protection on the Auckland Motorway system. This section not only is one of the busiest portions of the system, but has the highest public profile, and consequently the demand for safety improvement has intense public support.

The Board having been aware of the developments of the use of the movable barrier since 1986, commissioned a study tour in November 1988 which resulted in a full technical report for its use on the Auckland Harbour Bridge. This report has been accepted in principle by the National Roads Board in August of this year.

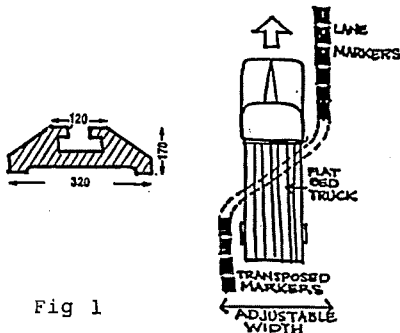


Fig 1

## 3. A Brief Development History

Mr John Quittner of Sydney was involved with the N.S.W. Department of Roads in developing a movable steel median which is now in use on the approaches of several bridges in Sydney including the Sydney Harbour Bridge.

The inventor set about designing a mechanically movable lane marker. The chain of linked units could be moved by feeding it into an S-shaped race which deposited the chain, one lane width away from its original position, the whole apparatus being slung beneath a flat top truck. (Fig 1)

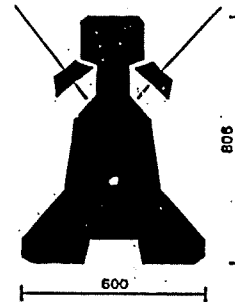


FIG 2

Flushed with the success of the invention it was marketed in the United States, where despite the problem of snow storms, the cleverness of the invention created immediate interest.

Roading Authorities in the U.S.A. suggested however, that what they really wanted was an easily transposable concrete barrier of the New Jersey type.

Mr Quittner set about modifying the patented transposing S-race and the New Jersey Barrier so that the barrier in one metre lengths could be transposed in the same way as the lane divider.

A prototype trailer with mechanically extendable arms to regulate lane width was successfully demonstrated in 1983 using a standard truck as the prime mover. (Fig 2)

Crash tests of the barriers were held in Australia in 1984 and followed with extensive testing in California, to U.S.A. Highways Authority's requirements in 1986.

In brief, these requirements require crash tests of vehicles weighing approximately 2050Kg, 1450Kg, 820Kg to impact the barrier at 7, 15, and 25 degree angles at speeds of 70, 90 and 100 K.P.H.

The barrier will deflect laterally when impacted by a vehicle. Some lateral deflection is advantageous due to energy absorption and the deflection helps in stabilising and redirecting the vehicle.

The deflection may cause some problems for oncoming traffic, however this is less critical than a potential head on collision. The barrier can be easily straightened by men with a crow-bar or by the Transfer Vehicle.

The following favourable conclusions of all the testing can be drawn:

(i) The chain-like nature of the barrier absorbs the energy at impact which minimises vehicle damage, lessens occupant velocity changes, creates a post collision trajectory which is close to the alignment of the barrier.

(ii) In no crash test ever, did a vehicle penetrate or vault the barrier.

#### 4. Developments in France

The licence to manufacture in France was granted in 1984 and the system was first used for work site protection on the A1 autoroute near the Porte de la Chapelle in Paris.

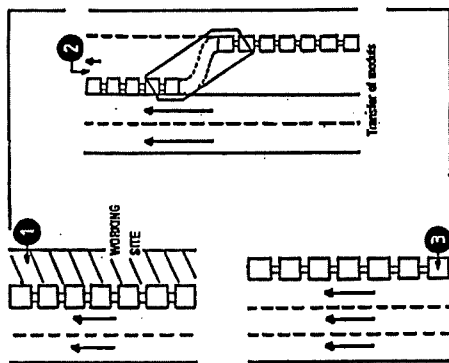


Fig 3

Subsequently it has been used on the upgrading of the viaduct Gennevilliers to the north-west of Paris. This was a conventional 2 x 2 structure with a central median. The median was removed and an additional lane added. The placement of the movable median barrier enabled the viaduct to be converted to a 3 x 2 situation in the morning rush period and the reverse in the evenings.

It has been working successfully every day for two and a half years now.

#### 5. Development in the United States

Usage in the United States has been confined to work site protection on freeway reconstruction. It is obvious however that the potential for use is enormous and at present more than 50Km of the barrier has been utilised for this purpose.

Under active consideration is their use for contra-flow bus lanes in the Chicago area and for use on the Golden Gate Bridge in San Francisco and the Coronado Bridge in San Diego. The study of the potential use on the Coronado Bridge has been of particular interest as it is of similar length and has comparable problems to the Auckland Harbour Bridge.

#### The Auckland Harbour Bridge

#### 6. Barrier Design Features

##### 6.1 General

The barrier shape is standard New Jersey "F" type, modified at the top to accommodate rollers for moving the barrier. The barrier unit dimensions are 813mm high by 610mm wide by 940mm long, with a mass of 670kg per metre. The barrier system meets the performance criteria set by the US Federal Highway Administration and will be satisfactory for New Zealand conditions.

The barrier units will be reinforced concrete (50MPa) minimum, probably utilising microsillita to improve durability. All exposed steelwork will be hot dip galvanised. The barrier will have replaceable rubber feet. There will be approximately 2200 in number. The shape and mass of the units are an important feature.

The bridge and the approach viaducts have structural capacity to withstand the imposed barrier loadings.

##### 6.2 Longitudinal Creep

Creep in the barrier string is controlled by the use of self-centering hinges. This is achieved by the use of preloaded tension springs. The self-centering hinge system is able to accommodate limited movement. However, on curves the barrier will need to accommodate additional geometrical changes in length. This is achieved by the use of hydraulically adjusted hinged units.

##### 6.3 Expansion and Contraction

The Barriers will be designed to accommodate the required thermal movement at the main expansion joint (310mm) and the five smaller joints (+50mm). Tests will be undertaken to show that a total of 40 barriers can move 1cm each without any hinge failures, thereby satisfying the expansion requirements. Barrier units fitted with hydraulically adjustable joints will accommodate any remaining expansion.

#### 7. End Treatment

The precise barrier termination accounts for the specific constraints at each end, e.g. site distance, existing obstructions, end anchorage lengths, overlap of fixed barriers, garaging space.

The movable barrier will be overlapped with permanent barriers to ensure that traffic is always protected. The Transfer Vehicle will always be protected by a barrier during its manoeuvring to and from the parking area. Individual wheel steering will mean that the gap between the two sets of barrier is kept to a minimum. At each end there is a 50 metre anchorage length to absorb impacts near the end of the barrier.

## 8. Lane Widths

### 8.1 Lane layouts

The Auckland Harbour bridge consists of three structures. The original four lane bridge and two x two-lane extensions added to either side of the original structure. The original bridge, on which the barrier system will operate, has a carriageway width of 12.80M (42'0") with four 3.2M (10'6") lanes. The installation of the barrier will reduce the carriageway width by 619mm (2'0") as there are no practical options for maintaining or increasing existing lane widths or decreasing the barrier width.

To achieve four x 3.05M lanes requires remarking of the outer lane lines and replacement of the existing centre lane with two unidirectional lane lines. There are several options for unidirectional lane lines-runway lights, glass prism strips, collapsible flexible posts. In common with all pavement markings, these lane lines must be durable and highly visible in all driving conditions. Flush mounted prism strips are proposed. The scheme includes retention of existing overhead lane signals.

### 8.2 Capacity

The introduction of the movable barrier reduces the existing lane widths by 150mm. Highway capacity is dependent on many factors but is strongly influenced by lane widths and lateral clearances. These two factors will be affected with use of a movable barrier.

There is no authoritative text that will predict the effect of a movable barrier on traffic on the Auckland Harbour Bridge. In fact, in France, after an initial settling in period, traffic volumes increased. Capacity implications have been assessed using the Transportation and Traffic Engineering Handbook which is the reference adopted in New Zealand for highway capacity evaluation. Some reduction in capacity is expected, especially initially.

It has also been suggested that traffic flow may actually increase due to the reduced anxiety and increased comfort level of all vehicles on the bridge due to the positive separation offered by the barrier.

### 8.3 Road Safety

A reduction in capacity may change road accident patterns. With the barrier, cross-over accidents will be prevented. They account for most of the road fatalities on this section. Concern has been expressed that trends in minor accidents of the non-crossover type, e.g. nose to tail, may increase. This type of accident rarely results in fatalities.

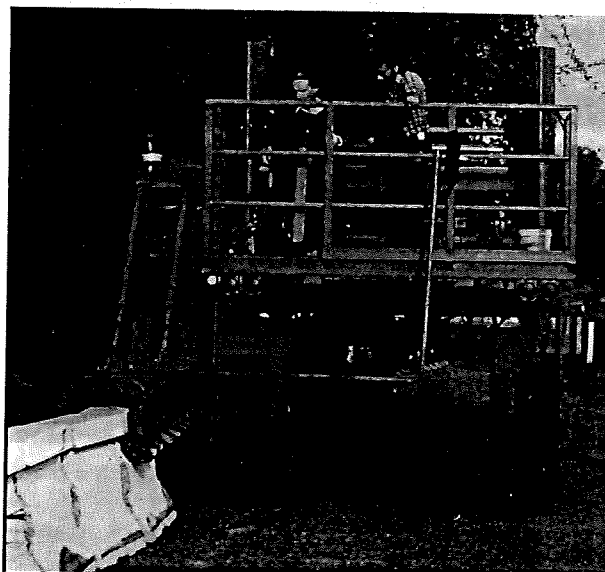
## 9. Transfer Vehicle

The barrier is transferred by a self-propelled vehicle specially designed for the operation. To maximise efficiency of operation and provide contingency for breakdown, two Transfer Vehicles are recommended.

The Transfer Vehicle will be approximately 12M long and 3.7M wide and 3.5 metres high and weigh 14 tonnes (21 tonnes laden). The vehicle will have capacity for a standard shift of 3.05M but this can be increased to 3.7M by "crabbing". To increase manoeuvrability, there is independent steering of each set of single tyred wheels. To ensure repeated accurate placing of the barrier, the vehicle will have an automatic guidance steering system with manual override.

The vehicle will be two-wheel drive and be powered by a 160hp engine. All mechanical, hydraulic and electrical equipment and tyres will be standardised to those readily available in New Zealand. It will have an operating speed of 8kph and a maximum road travel speed of 30kph.

The Vehicle will be fitted to comply with Ministry of Transport regulations for road worthiness. Also it will be fitted with hazard warning lighting, radio communications and safety equipment.



## 10. Autoguidance System

The barrier is shifted using a Transfer vehicle. The barrier needs to be placed accurately so as to consistently maintain 3.05 metre lane widths with no "regional" or localised departures and to aid efficient shifting of the barrier. (Irregularities can be handled but would slow the shifting).

Therefore, the barrier must be able to be placed repeatedly with precision (tolerance +15mm). To achieve this manually would be very slow. Also, overseas experience shows that even with top calibre operators, precise placement in adverse weather conditions is very time consuming. Therefore, automatic guidance (steering) of the Transfer Vehicle is necessary.

Various types of autoguidance are available. Systems which are not dependent on surface cleanliness or surface contact of a within pavement guide element are preferable. A long radiowave system is the preferred guidance method. The radiowave guidance system is a proven system in use for 30 months in Paris. The system used long wavelength radio waves. The frequency will be selected so as not to interfere with other long wavelength radio users. The system comprises double loop radio transmitter wires embedded in the pavement connected to transmitters located in the main Transfer Vehicle garage. The Transfer Vehicles are fitted with radio-receiver units on an adjustable arm.

**11. System operation**

**Barrier Layout for Standard Bridge Operation**

Standard bridge operation is defined as 5\*3, 3\*5 and 4\*4 lane operations.

Two Transfer Vehicles are used to shift the barrier.

A one lane transfer will take about one hour, inclusive of 20 minutes set-up. Normally one vehicle would be used at any one time but two could be used in tandem to effect a double lane shift in one hour. While operating, the Transfer Vehicle is always protected by the barrier and does not represent any obstruction to free and safe traffic flow.

5.00am - 6.00am

4\*4 Night Pattern to 5 South \* 3 North Morning Peak.  
Vehicle A moves from the southern to the northern approach.

9.00am - 10.00am

5 South \* 3 North Morning Peak to 4\*4 Day Pattern.  
Vehicle A moves from the northern to the southern abutment.

2.30pm - 3.30pm

4\*4 Day Pattern to 3 South \* 5 North Evening Peak.  
Vehicle B moves from the northern to the southern abutment.

6.30pm - 7.30pm

3 South \* 5 North Evening Peak to 4\*4 Night Pattern.  
Vehicle B moves from the southern to the northern abutment.

**Weekend Pattern**

During the weekend the barrier would be left in the 4\*4 pattern.

**12. Conclusion**

The Movable Concrete Barrier for the Harbour Bridge has received technical and funding approval from the National Roads Board.

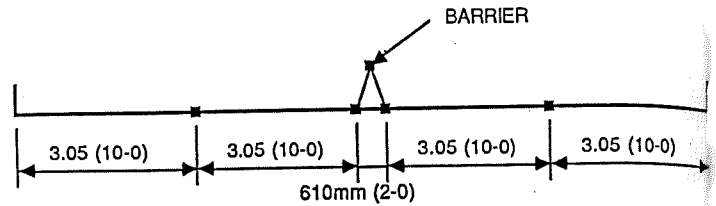
Final design, approval, manufacture and installation is programmed to be complete by November 1990.

When it is considered that 1500 tonnes of concrete will be moved four times a day, every week, every month to an accuracy of 10mm all within 30 minutes each time,

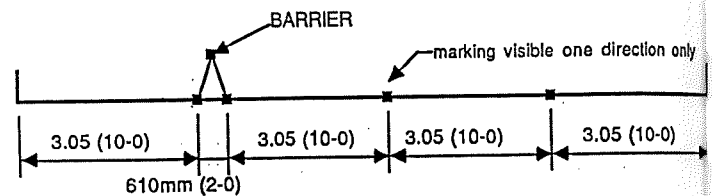
all this on one of the busiest stretches of highway in New Zealand, the project can be put in perspective.

The basic simplicity of the system is the proving factor, however good engineering will be imperative.

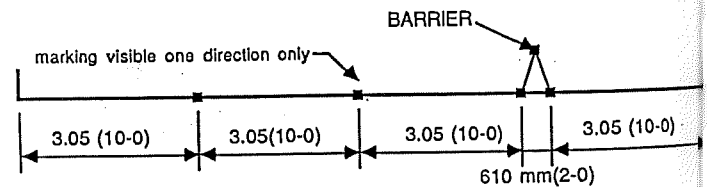
In any event, the commissioning will be exciting.



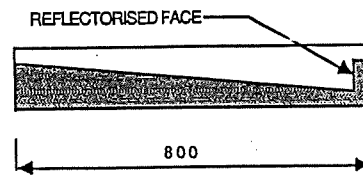
**OFF PEAK LANE PATTERN - 4 South 4 North**



**EVENING PEAK LANE PATTERN - 3 South 5 North**



**MORNING PEAK LANE PATTERN - 5 South 3 North**



**UNIDIRECTIONAL MARKER**

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