# THE PERFORMANCE OF AGED USED SEATBELTS

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## 1.0 INTRODUCTION

In Australia seat belt fitment has been mandatory in vehicles since 1969 and wearing has been mandatory since 1971. In some vehicles they have fallen apart from the constant use and exposure. It is therefore reasonable to assume that sometime before the complete in-service failure of such belts, there is a point at which they can no longer pass the minimum requirements of the Australian Standard and hence offer adequate protection in a crash. The Traffic Authority of N.S.W. occasionally receives reports of seat belts breaking in crashes, although there is no routine method of notifying these incidents. Where possible the broken components are obtained and the Authority logs a formal report. Reports have been made on fourteen such incidents in the last ten years. These were associated with eleven fatalities.

Previous experience has indicated that such failures are generally undereported because a) there is no formal system for reporting b) it is not evident who the responsible body is and c) the Australian population is less inclined to seek legal redress over such matters than, say, U.S.A. citizens.

In general the Australian Standard requires seat belts to restrain their occupant in an impact up to around 25g which generally equates to a 50 km/h head on collision. In some of the impacts in which seat belts failed, the damage to the vehicle appeared to indicate that the impact would have been of a less severe nature than that specified in the Standard. This supports the idea that the performance of seat belts deteriorates with age and use to such an extent that they do not offer adequate protection to the occupant in a crash.

In 1976 Chapman & Cameron conducted testing on old seatbelts with the aim of looking for correlation between the visual deterioration of a seatbelt and its performance. The sample consisted of 97 lap sash static seatbelts which hadn't been involved in crashes and no more than four years old. If the belt had visible signs of damage, then they waived the four year limit. Overall, 66 failed the Australian Standard E35 static assembly test. Of these, 29 had a webbing failure on a piece of hardware, twelve had buckle tongue engagement failure, three had other hardware failure, six failed by excessive slip at adjusters, five had stitching failures and eleven failed the buckle release force test.

A sample of 27 belts was obtained from vehicles which had been involved in crashes. The age of the belts was not controlled. Of the 27 belts, two had failure of the stitching or webbing adjacent to the stitching, six had buckle failures, one failed at the buckle adjuster and four failed the buckle release test force.

They tested various models seeking correlation of appearance to performance. They found that "measures and ratings of seatbelts were found which were capable of predicting to a limited accuracy, the strength of a seatbelt". However of the various models they tried for mechanics of failure, they found "the models do not adequately represent reality". They did not present any results in terms of the comparative ages of the seatbelts.

In 1985 Pickles and Aldridge conducted "an experiment to substantiate the suggested life expectancy of a belt ... is seven years". They found "a noticeable drop in both assembly strength and webbing strengths from that initially expected. However, this still leaves the majority above the minimum required by the New Zealand Standard NZS 5401:1976". In static tests of the webbing, they found that 80% of seven year old webbing would be expected to past the requirement of 18 kilonewtons. Sixty three percent of the seven year old seatbelt assemblies were expected to pass the New Zealand standard assembly test. Their sample consisted of 13 drivers' static lap-sash belts and four inertia reel drivers' belts. In phase 2 of this study their sample consisted of 16 static lap sash belts which were 12 years old, and 18 static lap-sash belt which were ten years old, to give a total sample of 34 belts. The results were not that clear, but they stated that 83 % of assemblies would have passed the requirements of the New Zealand Standard 5401:1982.

## 2.0 SAMPLE

This paper reports on the results of a recent series of tests on aged used seat belts conducted by the Authority in January 1987.

Belts were tested from motor vehicles manufactured over the ten year period from 1970 to 1979. (The nominal age of the seat belts was taken from the vehicles compliance plate). A sample size of ten belts from each year was chosen. Because the main aim of this project was simply to see if there was a problem, rather than quantify it, the belts were obtained in a fairly arbitrary manner without pursuing any particular make of vehicle. The belts were obtained from motor vehicle wreckers located in the Sydney Metropolitan Area. The vehicles were inspected to ensure that they had not been involved in moderate to severe head on collisions. That is, an effort was made to ensure that the belts had not been heavily loaded in a head on crash.

When collected the belts appeared to represent a fair cross section of seat belts of that age. They displayed a variety of degrees of fading due to sunlight, fraying where the tongue is located and staining. Most of the belts were fixed lap sash belts, although there were eighteen fixed lap belts and in the later years there was an increase in proportion of inertia reel automatic locking retractors.

## 3.0 STATIC TEST METHOD

The objective of the testing was not just to find the weakest link in each belt, but to determine the strength of the webbing, the stitching, the anchorages and the buckle-tongue engagement. Each seat belt was marked out and cut into the necessary segments for a test. A webbing length of approximately 400mm from the stitching or adjuster was necessary to ensure that a specimen could be held tightly in the grips of the tensile testing machine. For a test of webbing only, a specimen length of approximately 800mm was required to allow both ends to wrap around the grips.

All the specimens were tested in an Avery Universal Testing Machine at the load rate specified for webbing in the Australian Standard.A record was made from each test of load versus extension. This was checked by reading maximum load directly off the machine scale and measuring the extension at the completion of the test between the two mounting jaws. The testing was conducted in January 1987.

### 3.1 The Webbing Test

Where possible the section of webbing which by inspection appeared to be the most worn or faded was selected for the webbing test. If there was an area of abnormal wear then a second apparently less deteriorated segment was also tested.

### 3.2 Stitching and Anchorage Test

The anchorage with original webbing and stitching was tested to failure of the stitching. The anchorage was then fitted with new webbing and tested to failure.

### 3.3 Buckle and Tongues Engagement Strength Test

The original webbing was removed from the buckle and tongue and new webbing fitted. The Buckle and tongue were tested until failure of the buckle tongue engagement mechanism.

## 4.0 DYNAMIC TEST METHOD

In an attempt to evaluate dynamic performance, three complete seatbelt assemblies were tested on the Authority's sled in accordance with the Australian Standard AS2596 for the dynamic testing of seat belts. A pulse of 24g was used on a rebound style sled using a TNO 10 adult dummy. The belt loads were measured by mounting four load transducers on the webbing as described in the calibration part of the Australian Standard. This specifies transducers at the top and bottom of the sash and at each end of the lap webbing. If there was a webbing or stitching failure in the first dynamic test, it was replaced with new webbing and tested a second time to find the next weakest link in the hardware. In each of the first tests the belt broke at the stitching on the top part of the sash strap. It is recognised that the first test may have affected the outcome of the second test.

## 5.0 RESULTS

Figure 5.1 shows the results of the dynamic tests.

Figures 5.2 to 5.5 show graphical analysis of the static tests.

| Test No. | Belt Age | Breaking Load | Description of Break |
|---|---|---|---|
| 1 | 1970 | 6.90 KN | Stitching broke at top of sash. |
| 2 | 1975 | 1.19 KN | Single row of stitching broke at top of sash. |
| 3 | same belt with new webbing | <10 KN | The buckle mounting consisted of webbing, this broke on a single row of stitching attaching the buckle. |
| 4 | 1977 | 6.43 KN | Stitching broke at top of sash. |
| 5 | same belt with new webbing | >10 KN | The buckle mounting consisted of webbing. This broke at the stitching attaching the buckle. |

Figure 5.1 Dynamic Test Results.

Fig. 5.2 Average Breaking Strength

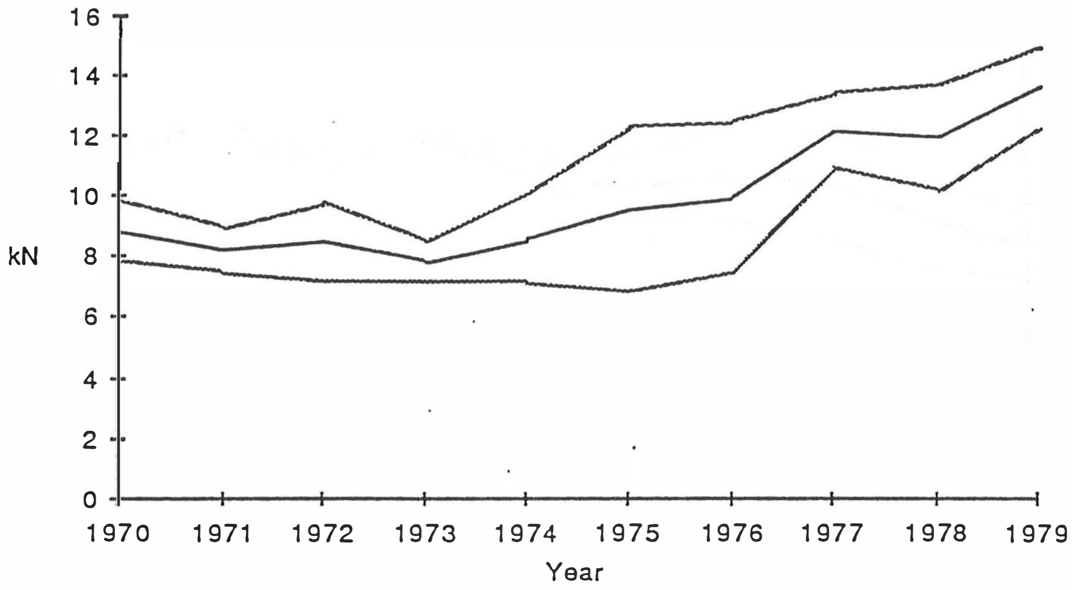



Fig. 5.3 Average Stitching Strength

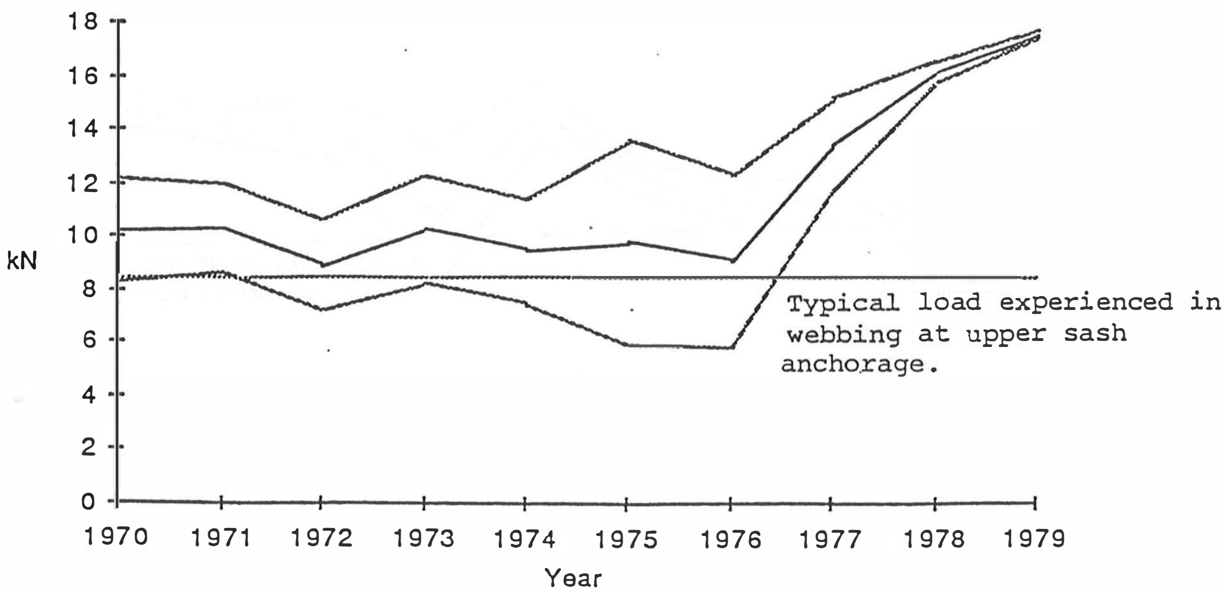


Fig. 5.4 Average Webbing Strength

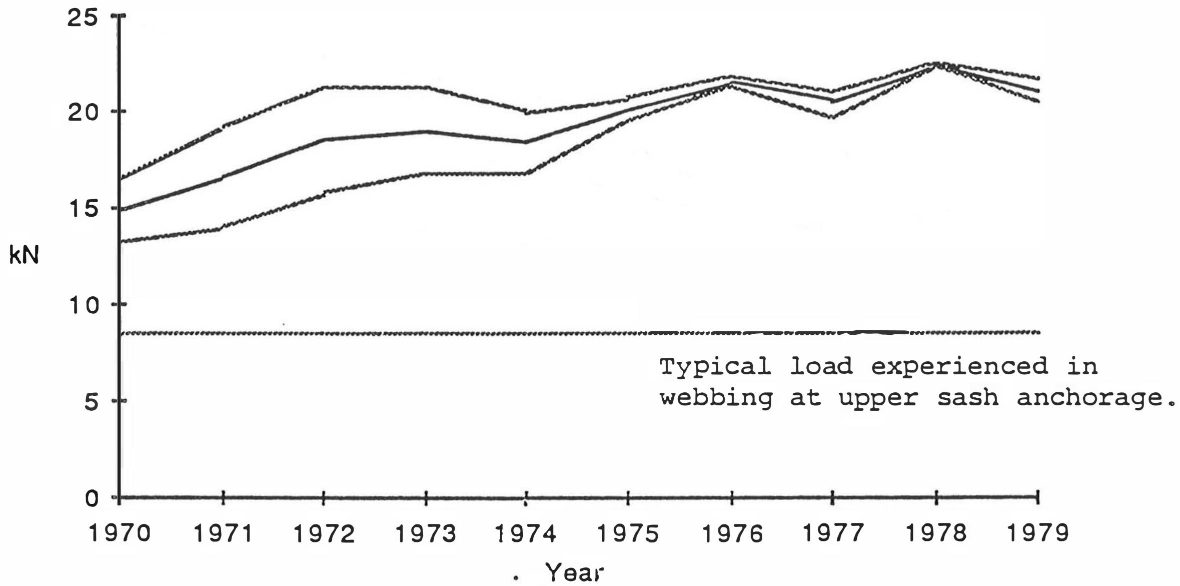
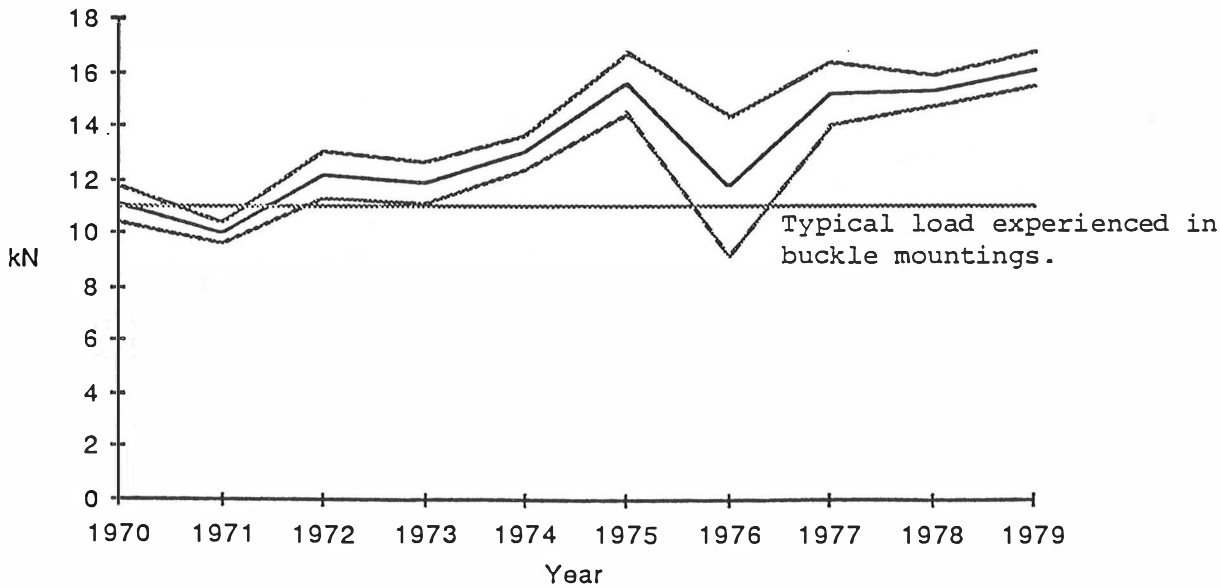



Fig. 5.5 Average Buckle Strength



## 6.0 DISCUSSION

The Australian Standard for seat belt webbing requires it to withstand a static load of 22 kiloNewtons in the dynamic test to the Australian Standard. Typical dynamic loads experienced by the webbing are of the order of eight and a half kiloNewtons in the top of the sash and seven kiloNewtons at the ends of the lap. The loads at the buckle-tongue engagement or at this stalk or webbing link is hence deduced to be of the order of eleven kiloNewtons. The ability of webbing and associated hardware to withstand these loads is used as a general indicator about which parts of the system might continue to pass the Australian Standard.

Probably the most useful tools to analyse the results are graphs drawn of age by breaking strength. In Figure 5.1 it can be seen that in general there is a decline in the average strength of seat belts as they get older. This downward trend is present in all components which make up a seat belt and is shown by the slope of the individual component graphs. Deviations from the general trend are probably explained by the arbitrary sampling method of collection of the seat belts, and their varying usages and exposures.

### 6.1 Webbing strength

The average minimum webbing strength was found to decrease at a fairly constant rate over the ten year period and varied from approximately 15 kN to 22 kN for the range of samples tested. Considering the small sample size, very few variations were obtained away from the general trend. The webbing does degrade the older it gets. This may be due to sunlight, staining, fraying due to general wear and tear or a combination of all three. The webbing appeared to be generally adequate even when 17 years old. The webbing changed from nylon to polyester from 1969 to 1971, but the effect of this change (if any) should be mostly prior to this study's sample. No attempt was made to identify the webbing materials in the sample belts.

### 6.2 Buckle strength

The average minimum buckle strength of the seat belts tested varied from approximately 10 kN to 60 kN at a constant rate according to the seat belts age.

There were, however, many different buckle designs used in the ten year period, thus making it difficult to determine whether the strength of specific buckles diminishes with age. From the results of the testing, it has been determined that the older buckles are inferior in strength. This may be due to wearing of the metal components which make up the buckle, the poor design of the buckle, or the general deterioration of the componentry.

## 6.3 Stitching strength

The average minimum stitching strength was almost constant from 1970 to 1976 and rose sharply from 1976 to 1979. This might have suggested that the strength of stitching deteriorates rapidly after about 8 to 10 years, because from 1976 to 1979 the strength changed from approximately 9 kN to 18 kN. In 1973 the material used in the stitching was changed from nylon to a stronger more durable polyester thread. This may be a factor in explaining this change in stitching strength. No attempt was made to identify the specific thread material in each test.

## 6.4 Dynamic Test Results

Although only five dynamic tests were conducted on three seatbelt assemblies, some comments can be made.

In the three primary tests on the seatbelt assemblies, the mode of separation was always stitching breaking at the top anchorage on the sash. The loads at separation of 6.90, 1.19 and 6.43 kN were all noticeably below the average stitching strength of 10 kN for 1970 to 1985, as observed in the static tests.

As a possible lesson for future design, it has been superceded by two changes, firstly the change of stitching thread and secondly the change to retractor belts, which have no stitched joint at that point. However the lesson may be, that all belts prior to that are suspect.

In the two belts which could be tested a second time, both failed in the stitching attaching the buckle strap. The loads measured in both exceeded the scale of the recording equipment at 10 kN. In most modern belts the buckle to vehicle link, is a rigid housing or semi rigid stalk.

## 7.0 CONCLUSION

The tests indicated that there was a general decline in the strength of all components of the seat belt system as they become older. This deterioration appeared to be most noticeable from eight to twelve years old.

At the outset this study only aimed to find out if there was any deterioration of seat belts with age and to give a general idea of when this deterioration occured. If there was evidence of deterioration it was considered this would support the case for bearing the costs of a more elaborate study with a stricter sampling technique. Arrangements are now in hand to conduct such a study.

## 8.0 FUTURE WORK

The aim of the new test program is to determine the degradation in seat belt strength over time, with a view to quantifying when the seatbelts degrade to the extent that their strength is inadequate to provide an acceptable level of occupant protection and to see if a practical criterion can be identified as to when seatbelts require replacement.

It is planned to examine six years of belts covering the most critical age range. If the deterioration in stitching strength is fully attributed to the change from cotton to polyester thread in 1975, then the identification of this most critical age range becomes more difficult. It might be decided to retain the same range of years tested, whilst sampling from each second year. To reduce the variability within the sample selected, it is planned to select two paticular brand lines and styles or seatbelts. One will be an Australian made belt and the other imported. A total of 96 belts will be tested, with 16 from each year. In the interests of consistency and availability it is proposed to select vehicles which have been and continue to be registered in the Sydney region. Further stratific-ation of the sample will be attempted using the following parameters:-

- average annual distance travelled (perhaps 10,000 km per annum as a minimum)
- one owner vehicles (to try to obtain accurary in the vehicles history)
- whether or not the vehicle has been garaged regularly
- type of use of the vehicle, that is, daily commuting or weekend use only.

This would be determined by means of a questionnaire to vehicle owners. The registration records of the N.S.W. Department of Motor Transport will be used to identify the vehicles from which the sample will be drawn. The registration records will allow identification on the following criteria, make, tare mass, year of first registration, body type, ownership history.

Owners of the required vehicles will be offered new belts in exchange for their old belts.

The seatbelts will again be tested in segments to allow evaluation of webbing, stitching, buckle assembly, anchorages and retractors. An attempt will be made to replace the static test with a dynamic one. Loading will be applied to the individual components at the load rate typically recorded in full dynamic testing of seatbelt assemblies. The components will be loaded to failure and the load rates and load at failure will be measured by force transducers. If this dynamic test method is too difficult to achieve the program will revert to static testing.

## 9.0 REFERENCES


1. Standards Association Australia, Testing Seat Belts AS 2597 (1983), Seat Belt Webbing AS 1753 (1983).

2. Pickles, R. & Aldridge A.E., Vehicle Seat Belt Degradation, Auckland Industrial Development Division, ISSN 0111-1566. No. G146.

3. Chapman, C.C. & Cameron, M.A., the Effect of Usage on Seat Belt strength (1976), published in the proceedings of Seat Belt Seminar conducted by the Commonwealth Department of Transport.