THE FRONTAL CRASH PERFORMANCE OF A CHILD RESTRAINT SYSTEM (CRS) AS A FUNCTION OF SEAT GEOMETRY, USING ISOFIX ANCHORAGES.

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INTRODUCTION

Child Restraint Systems in the UK and elsewhere are designed both for the user in the market place and to comply with a number of requirements specified in National and International Standards. The majority of those sold in the UK are approved to ECE Regulation 44 -03[1]. Within this standard different requirements apply to different child age/mass groups. The two youngest groups are: Group 0 [0 to 9 months], Group 1[9 months to approximately 3.5 years].

One of the factors considered essential by the manufacturers for forward facing CRS, for all but the cheapest seats, is the facility to recline the occupant during travel.

The installed angle to the horizontal at which the CRS shell base is set for upright or reclined travel is dependent upon what the manufacturer deems desirable for occupant comfort and hence purchaser acceptability. Provided the CRS meets the requirements of the national or international standard applicable in the market place, the product is deemed acceptable and can be sold.

It has been observed during comparative evaluations of current adult belt retained CRS that the angular velocity of the manikin's head about its shoulders is greater in the reclined position than the upright during deceleration events. Since an increase in angular velocity suggests potentially greater loading on the head / neck as the chin strikes the chest it was felt that optimising a desirable range of seat inclination would be of benefit.

It was decided to employ a CRS of the proposed 4 point ISOFIX design to eliminate the influence of the adult belt system and vehicle seat cushion, therefore offering a worst case scenario.

This paper details comparative frontal impact testing / data analysis to ECE R44 test requirements at CRS seat base inclination angles ranging from 0°-90° to the horizontal. A CRS adapted to allow indexed rotation of the seat and occupant about the occupant's seated centre of mass was constructed to facilitate this (see figure 1).

The tests employed a TNO P3 manikin which with its limited neck structure has recognised limitations. However it does serve to offer a tool for comparative assessment of performance, which it is felt must to an extent be reflected in real child occupants.

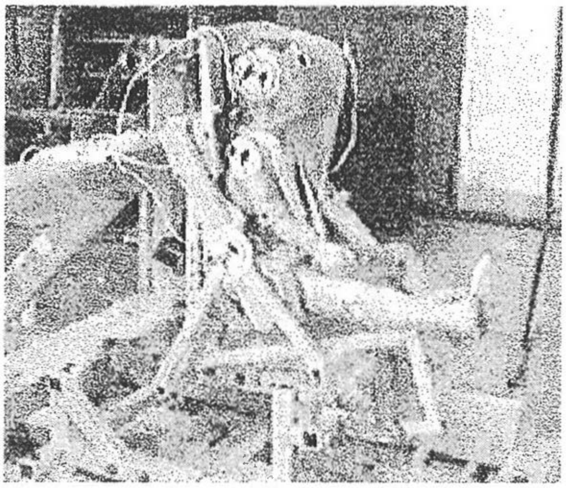


Figure 1

Testing was conducted at the dynamic test facility of Middlesex University's Road Safety Engineering Laboratory.

The parameters upon which these evaluations were based are essentially those acceptance criteria specified in ECE R44 for dynamic approval, chest resultant acceleration (<= 55g); chest vertical acceleration, from the chest towards the head (<= 30g). Head excursion as defined in ECE R44 has been substituted by head travel (target to target) due to the difficulty of defining a test seat CR point with the rotating test seat fixture. In addition to the above, head resultant deceleration and head angular velocity are presented.

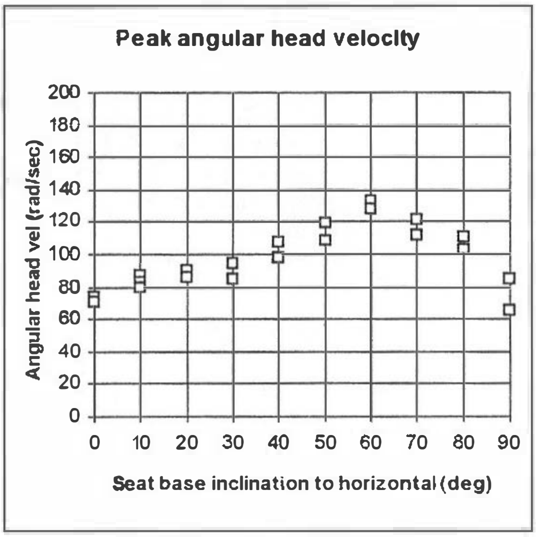
DYNAMIC RESPONSE OF P3 MANIKIN

The following summarises the significant response data obtained. All the tests were frontal impacts, the majority reflecting forward facing CRS. However, the potential for rear facing CRS in this age/mass range also exists. An evaluation of the CRS in such a configuration was similarly conducted employing recline angles as before ranging from 0°-90° to the horizontal.

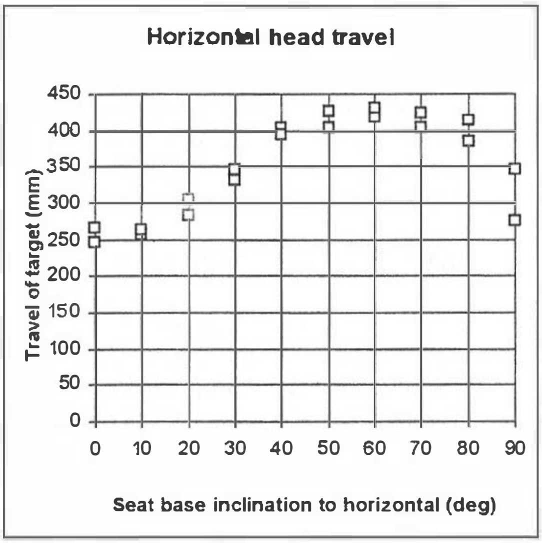
A brief summary of the more significant data collected, namely manikin head/chest accelerations, manikin head travel (horizontal/vertical) and manikin head angular velocity, is outlined in the following pages. Additional data relating to harness loads was also collected, but is not included here for reasons of brevity.

FORWARD FACING ISOFIX CRS

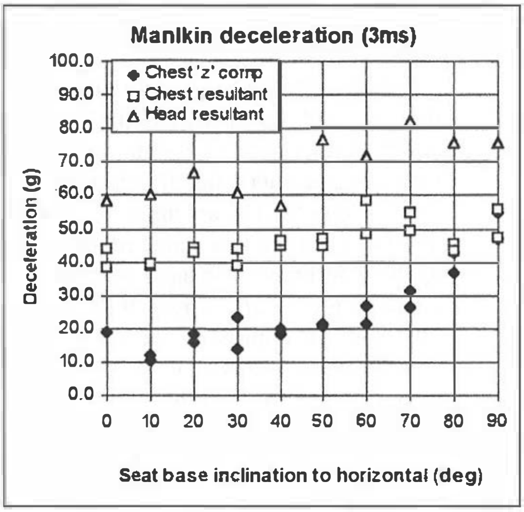
It is apparent that as expected, the angular velocity of the head about the shoulders increases with seat base inclination, peaking at a seat inclination of 60°, at which point it is found to be some 40% higher than that at 30° (a typical normal 'upright' seat inclination).



In addition it has been found that horizontal head travel peaks at a similar position.

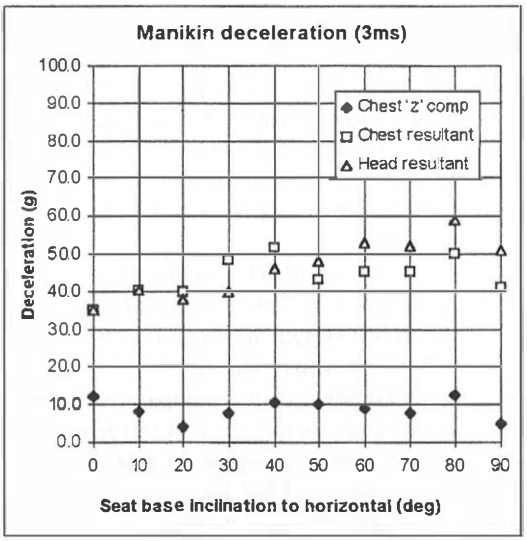


As expected, compressive loading of the spine increases with inclination angle exceeding the 30g acceptance limit in the 60° -70° base inclination region. Chest resultant deceleration would appear to increase steadily with seat inclination peaking in the region of 60° before decreasing again, finally increasing once the seat base is vertical. Head acceleration data is recognised as less reliable due to limitations of the neck construction, however, results in the region up to 50° would appear valid for comparative purposes, above this the results are compromised by contact between head and upper legs later in the event.



REAR FACING ISOFIX CRS

It is of interest to note the increase in performance offered by rear facing as opposed to forward facing CRS.

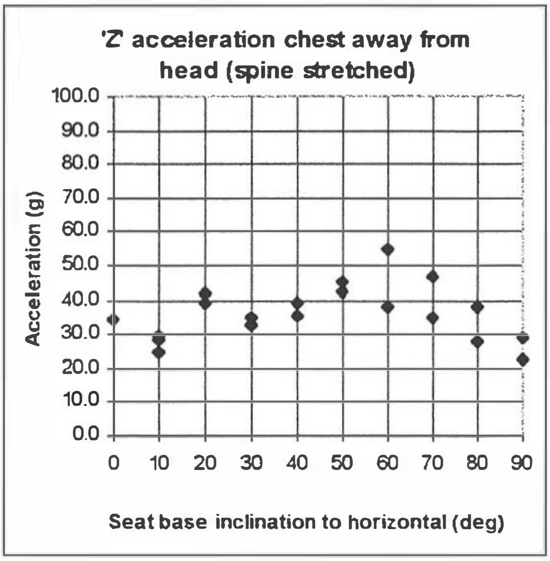


It can be seen that significant advantages are available, the head closely mirroring the chest data especially in the lower recline regions.

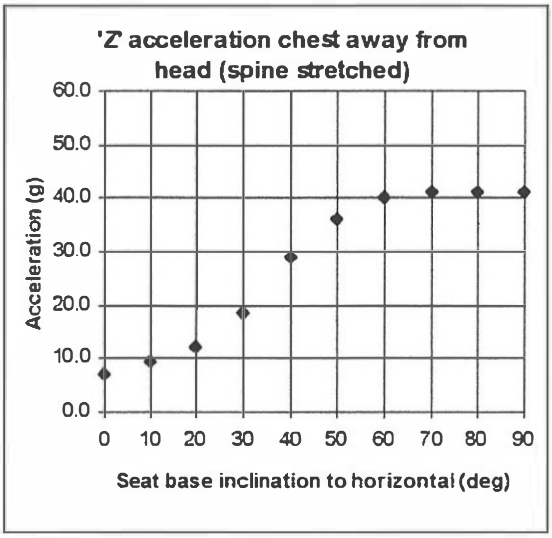
DISCUSSION

The seat inclination angles addressed may at first sight seem excessive. However, it is apparent that in the market place today forward facing child restraints are available which allow a parent to recline the occupant from a seated to a sleeping position. When placed upon the ECE R44 test seat CRS base angles of up to 50° to the horizontal were measured. It should be noted that with conventional adult belt retained designs installed upon a vehicle seat cushion, the CRS angle to the horizontal will change during a dynamic event. It is clear from the data that as anticipated rear facing CRS are of greater benefit to the occupant in a frontal impact. It is worthy of comment that in both front and rear facing cases tensile chest 'z' loading has proved greater at larger incline angles.

Forward facing peaked above 50g at 60° seat incline.



Rearward facing peaked at over 40g at seat inclinations above 60°.



The injurious nature of tensile loading of this magnitude is at present not quantifiable. Further research is scheduled to investigate the nature of the loading associated with the decelerations indicated above.

CONCLUSIONS

Analysis of the forward facing data indicate that seat base inclinations in excess of 50° are undesirable from both chest 'z' and chest resultant perspective.

REFERENCES

[1] ECE R44 (Economic Commission for Europe Regulation No 44) amendment 03 Uniform Provisions concerning the approval of restraining devices for child occupants of power-driven vehicles (Child Restraints)