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MYLES, B.
ICI Fibres, Pontypool, U.K.

Assessment of Soil Fabric Friction by Means of Shear

Evaluation du frottement sol-textile à la boîte de cisaillement

This paper considers the frictional effects of placing a geotextile at the shear interface in a soil. It details an indexing method obtained by shearing a standard sand in a shear box, without loss of shear area, across a flat, fixed and supported fabric, varying both normal loads and rate of strain. It describes the scope of the investigation and discusses the results.

Cette communication examine l'effet sur le frottement de placer un géotextile au niveau du plan de cisaillement dans un sol. Elle présente une méthode d'indexation obtenue en cisaillant un sable standard dans la boîte de cisaillement, sans perte de surface de cisaillement, à travers un géotextile plan. La force normale et la vitesse de déformation sont variées. Le rapport décrit les recherches qui ont été faites et discute les résultats.

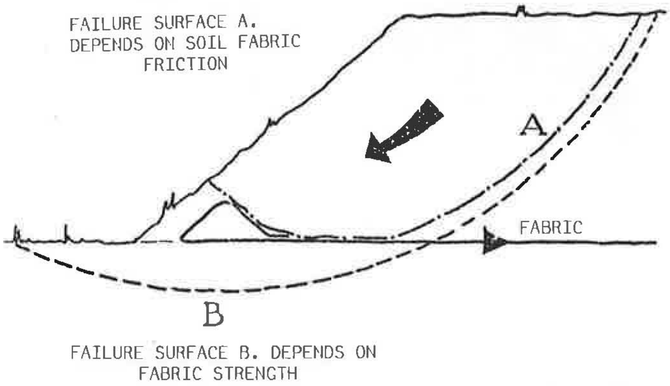
INTRODUCTION

When a fabric is placed in soil to perform the function of filtration, separation or reinforcement, its surface properties may be such that they act as a plane of discontinuity, so encouraging slippage or movement. One of the critical factors in preventing the fabric from becoming a feature of discontinuity is that of soil/fabric friction. It will be readily appreciated that geotextiles with similar strength and filter characteristics can often have greatly varying surface textures which might well indicate differing frictional properties, therefore an indexing system for comparison is necessary. The introduction of high strength reinforcing fabrics - particularly those used in embankments - further emphasizes the need to understand more fully the frictional characteristics of fabrics, especially when estimating and predicting failure mechanisms.

Purpose and Scope of Investigation

The purpose of the investigation was to assess what effect the inclusion of a geotextile has at the shear interface in a soils system, in order to provide the basis of a frictional indexing system.

In this investigation we examined four different fabrics of varying constructions and surface textures with one standard soil, under three loading conditions, and compared these results against the shear value of the soil itself; and also against the frictional resistance of the soil and a polished mild steel plate. The four fabrics tested were representative of the principal geotextile constructions available, but the apparatus is capable of assessing the soil/fabric/soil frictional behaviour of all types of fabrics used in Civil Engineering.

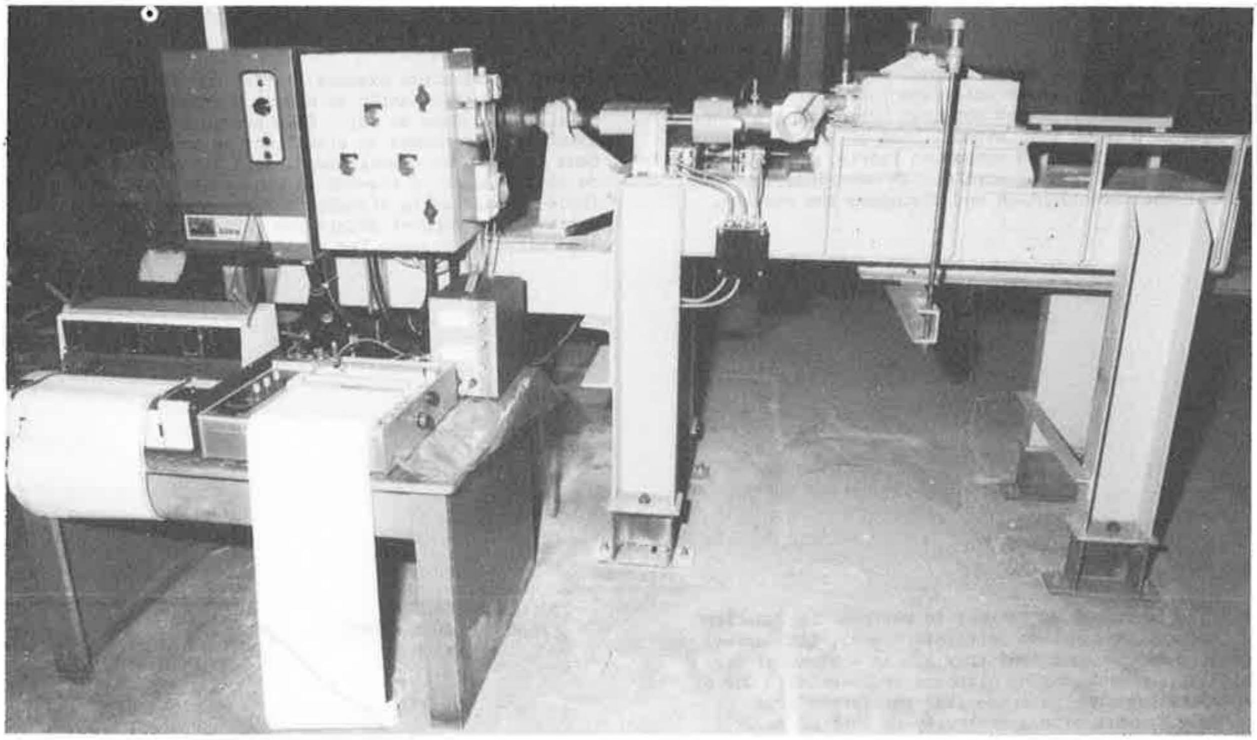


Outcome of the Investigation

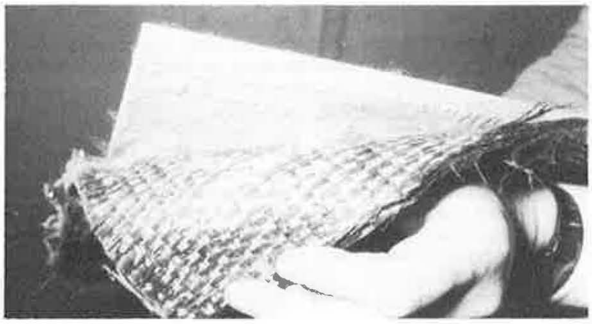
The investigation demonstrated that all four fabrics tested possessed good to adequate frictional characteristics, in spite of their very dissimilar surface textures. These tests, however, were performed with a single soil, rigid fabric, system; further investigations with dual soils systems, and cohesive and undrained soils, might well produce differences in frictional resistance between any one of these fabrics and another.

Methods, Materials and Equipment

The investigation utilized a large shear box modified to allow the inclusion of a geotextile. The shearing mechanism on this equipment permits strains, and varying loads and rates of strain, beyond those normally encountered in direct shearing of soils.



The apparatus consists of a 0.1 m^2 square shear box which is pulled over a larger lower box 0.35 x 0.40 m which has been fitted with a fabric clamping frame. The maximum available depth of the upper box is 10 cm and 12 cm in the lower box. The shear force is applied by a 1.2 kW variable speed motor through a 60:1 reduction gear by a positive buttress thread drive. The range of strain rate can be varied from 5 mm per minute to 100 mm per minute. The normal load is applied by a moving cantilever yoke capable of applying a vertical load between 30 kN/m^2 to 300 kN/m^2. The shear force is monitored by a 100 kN low range sensitive load cell. The standard soil selected was a Leighton Buzzard sand 0.60 - 0.85 mm (US sieve 20 - 30). The sub-rounded and close graded nature of the sand assisted in achieving reasonable void ratio reproducibility during the test and allowed the dry sand to be placed without extensive compaction procedure. Leighton Buzzard sand is a widely used standard sand both within the UK and elsewhere and readily available commercially.



In the experiments, the lower box was fitted with a series of rigid wooden plates and the upper shear box fitted with a Leighton Buzzard sand (BS 12).

The fabrics assessed were:

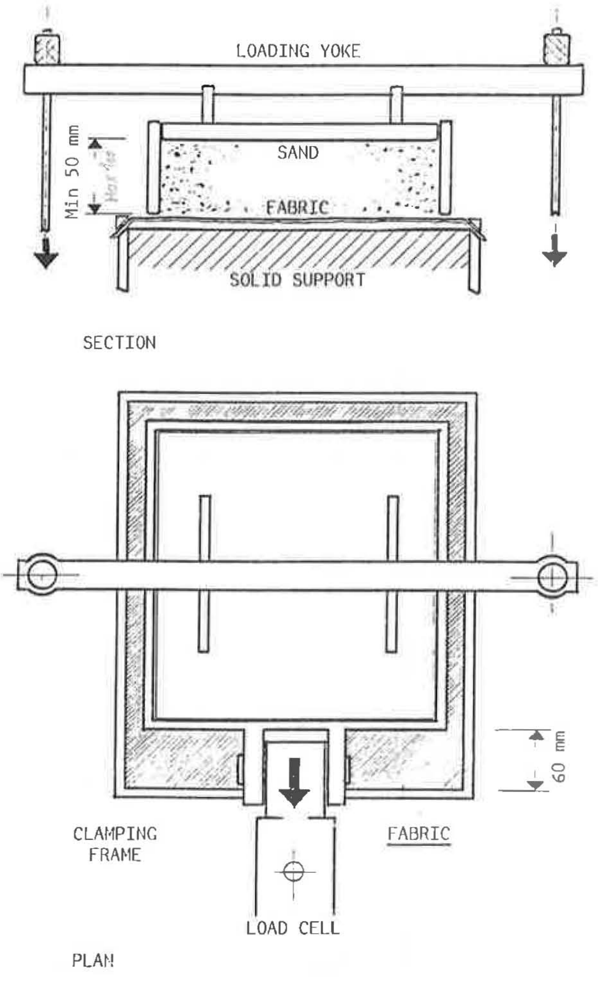
1 Needle-punched polypropylene.

2 Heat-bonded polypropylene/polyethylene.

3 Heavy weight woven polyester construction.

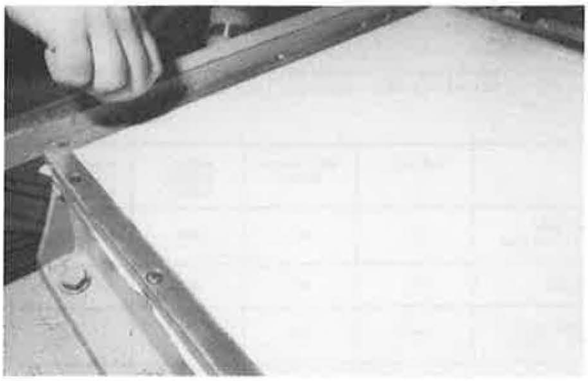
4 Light weight woven polypropylene construction.

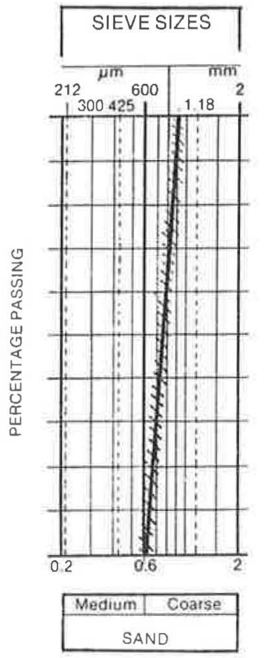
The upper wooden plate which supports the fabric in the lower box should be not less than 1 cm. thick and the fabric should be firmly glued to its surface.



SOIL-FABRIC SHEAR BOX

Hardwood-ply on blockboard will form a good base. The glue selected should be one which hardens to a brittle state and applied so that it does not penetrate through the fabric. Synthetic solvent glues should not be used as they may affect the fabric and have poor resistance to shear because they are not rigid when set. The fabric is cut to extend beyond the wooden plate and under the clamping ring.





PARTICLE SIZE DISTRIBUTION

LEIGHTON BUZZARD SAND USED AS THE STANDARD SOIL.

The upper box is then placed in position over the fabric and the sand is carefully poured and levelled to a depth of not less than 50 mm. The maximum 2 normal load is applied to the sand/fabric system for a period of 15 minutes prior to the shear force being applied. The normal load is then reduced to the lowest level and the shear box pulled across the fabric at a constant rate of strain. Due to the extended area of the lower box the full 60 mm. of travel can be utilised without loss of shear area; this allows a clearly defined residual shear force level to be established.

The normal load is then removed, the box repositioned and the experiment repeated at the intermediate normal load level, and again at the ultimate normal load level.

Initially, the sand was removed after each shearing procedure and the fabric replaced, but subsequently it was found that when using dry, non-cohesive soil, at least three shear passes could be made on the same fabric without affecting the results.

To establish boundary controls once all four fabrics had been tested, the fabric was first replaced by a polished mild steel plate, and frictional values ascertained at differing normal loads and rates of strain. Then similar tests were performed after the mild steel and wooden plates in the lower box had been removed and replaced by standard soil.

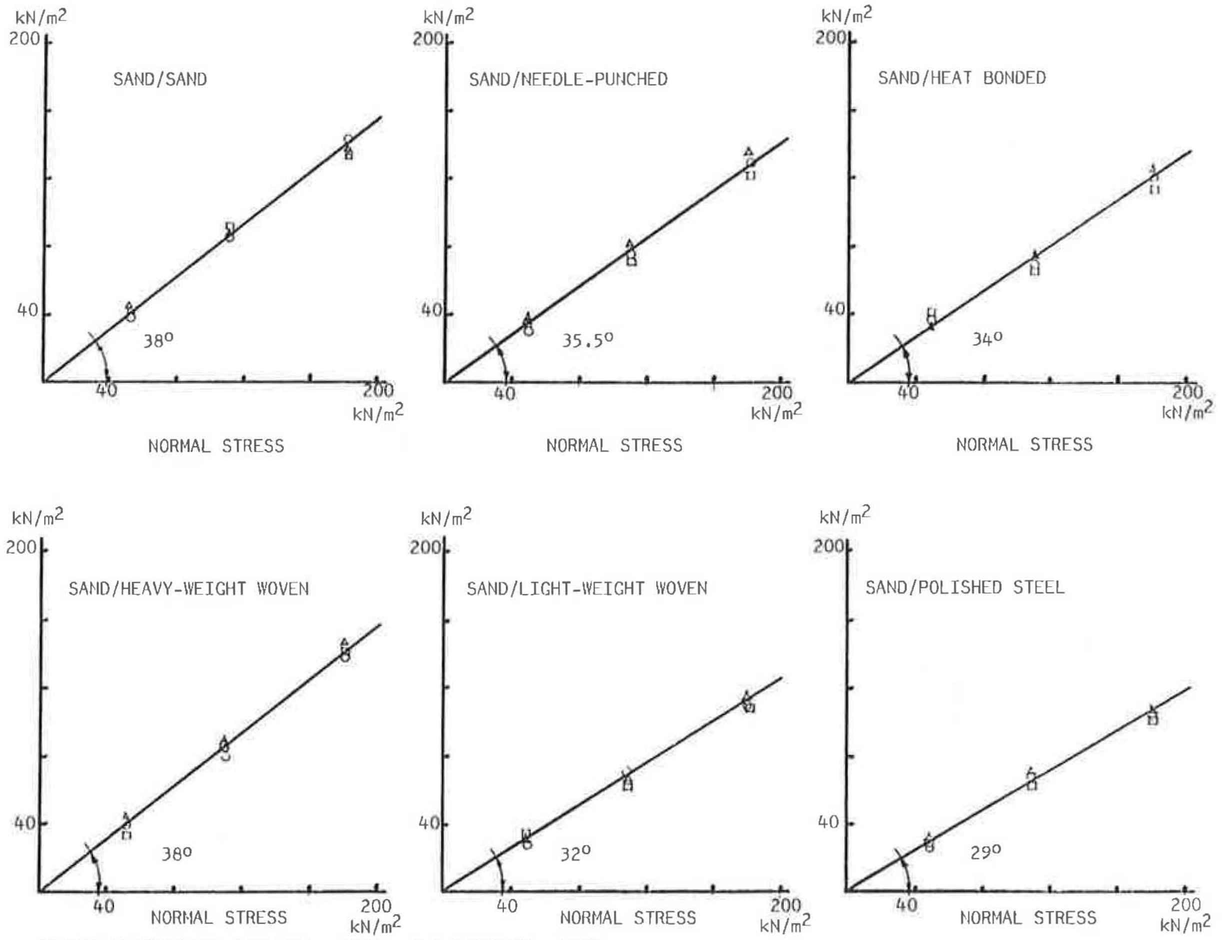
Results

The results were logged by recording the shear load on a single pen plotter, and by measuring the horizontal and vertical movement of the upper shear box by transducer readings to a three pen plotter.

The three shear stresses and normal load for a particular rate of strain régime were then plotted and a line passing through the origin was drawn connecting the points.

Discussion of Results

The results tend to confirm work done on smaller shear boxes with matching upper and lower boxes. However, the ability to achieve high strain without loss of shear area is important as most fabrics do not establish a realiable residual shear level until movements in excess of 10 mm. have been induced.



ANGLES OF FRICTION BETWEEN - SAND - GEOTEXTILES - STEEL

SAND - LEIGHTON BUZZARD SAND 0.85 - 0.60 mm (US SIEVE 20 - 30)
VOID RATIO UNDER TEST 0.60 - 0.65

RATES OF STRAIN
△ 10 mm/min
○ 25 mm/min
⌑ 75 mm/min

Coarse grain sand used as a standard soil shows very little sensitivity to the rates of strain. This was to be expected and is confirmed by J H Schmertmann*.
The object of these experiments however was to produce an indexing system and therefore the lack of effect of rate of strain can be regarded as a positive result. In practice, though, soil is very rarely of the type used in experiments, and in soils with cohesive characteristics and undrained conditions, the rates of strain may, in fact, have some relevance.

In many reinforcing applications the frictional resistance of the fabric is mobilized only after fabric extension caused by significant movement of the structure. It is therefore essential that the residual soil/fabric friction value be used when calculating structural stability.

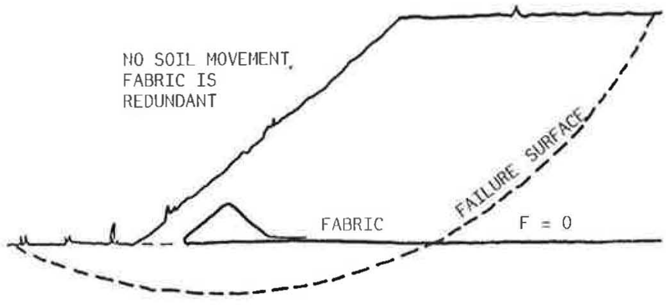
Conclusions

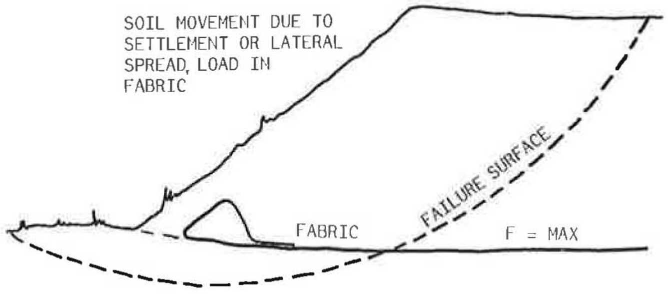
Many specifying authorities and geotextile committees (eg: ASTM, RILEM) have expressed the view that test procedures should be developed to assess soil/fabric friction characteristics in order that they can be better defined.

SOME TYPICAL SOIL SUPPORTED FABRIC FRICTION RESULTS
OBTAINED ON A SMALL CONVENTIONAL SHEAR BOX APPARATUS.

	SOIL/SOIL	HEAT BONDED FABRIC	NEEDLE PUNCHED FABRIC	MONO FILAMENT WOVEN FILAMENT
FINE SAND 0.1 - 0.2 mm	43°	40°	42°	42°
FUEL ASH	44°	36°	38°	40°
COARSE SAND 0.2 - 1.0 mm	45°	39°	44°	40°

*Laboratory Shear Strength of Soil A.S.T.M. STD 740



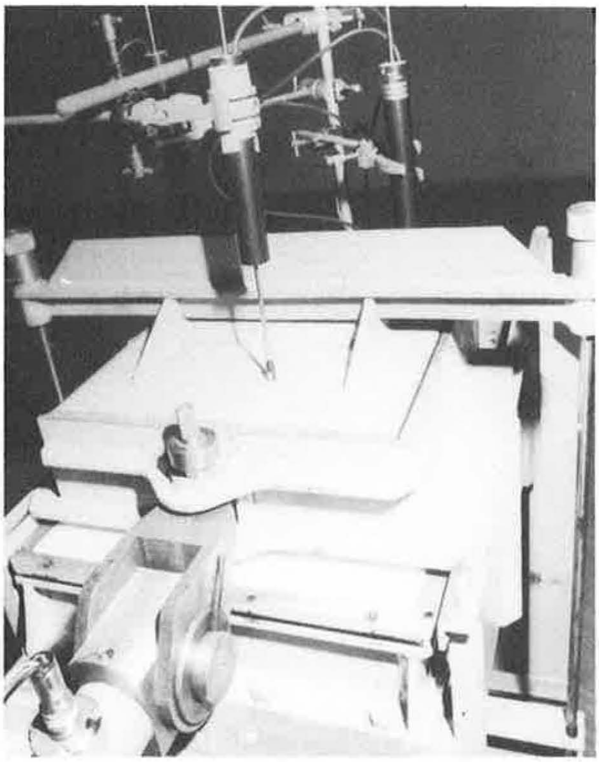


The work described in this paper follows closely the principles advocated, viz index testing by standard soil in a shear apparatus.

Practical experience over the last ten years would indicate that the majority of geotextiles have adequate frictional resistance for typical separation and filtration applications and it is the author's view that using the indexing procedure described a lower limit of say Tan soil/fabric ÷ Tan soil/soil 0.75

could be applied as a standard for geotextiles when used for filtration and separation.

In the case of geotextiles designed for reinforcing applications - where their performance particularly concerning load transfer from soil to fabric is critical in the structure - more exacting standards are required. This will necessitate an appropriate programme of testing along with further experimentation and analysis.



However, it must be borne in mind that in most geotextile reinforcing applications the area of fabric in contact with the soil and consequently its ability to generate a frictional anchorage even at moderately normal loads, usually far exceeds the breaking load of the fabric. Nevertheless, the engineer should be encouraged to use wherever possible any simple anchoring system such as returning the fabric round a granular bun providing that the cost for this anchorage is not excessive.

ACKNOWLEDGEMENT

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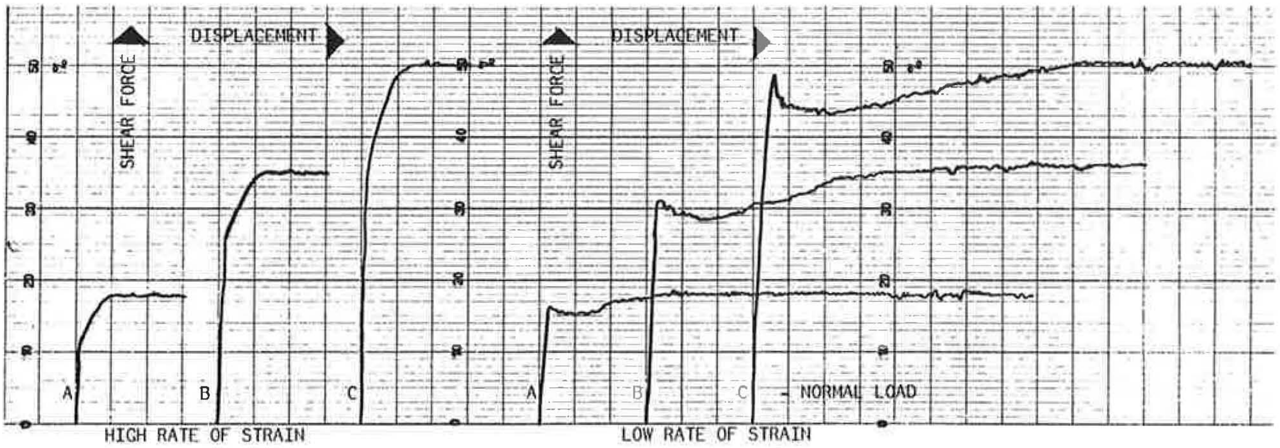

TYPICAL INITIAL AND RESIDUAL SHEAR FORCE BEHAVIOUR WITH RATE OF STRAIN