UON
University of Northampton
Faculty of Arts, Science & Technology

PROJECT REPORT:

Testing of Fire Control Switch

BACKGROUND

When a fire alarm is activated all the lifts installed in the building are supposed to go down to the ground floor and remain there the entire time the fire alarm is active. Firefighters can then use the 'fire control' switch located at the fire service access level, outside of the well (and optionally in the car) to initiate firefighters service [1].

For this project ARUP (UK) commissioned work to test a standard "Fire Control" ('firefighter's) lift switch (see Figure 1 [2]).

Figure 1. "Fire Control" (firefighter's) switch [2].

THE AIM AND OBJECTIVES

The aim of this project is to test a standard "Fire Control" switch design. The investigation is to determine the load/ force range required to deform the switch frame structural elements.

The objectives are to determine:

- the force required to operate the switch (open/close),
- the force to bend the switch frames,
- the force to bend the Express drop key or break the hinge.

The loading conditions to be considered are when the switch is operated by a standard unlocking key (the Express "drop key") which fits the unlocking "drop key" mechanism. An example of the switch damaged during a fire event is shown in Figure 2 [2].

A new "Fire Control" switch and the Express "drop key" was provided by ARUP (UK) for testing purposes.

The control switch case ('back box') structure has two steel frame plates ('cheeks' on either side of the entered key). The plates have a "labyrinth" (see Figure 3) designed to ensure that only the proper key could be turned, i.e. any improper/ vandal generated tool would hit the 'cheeks' and fail to turn.

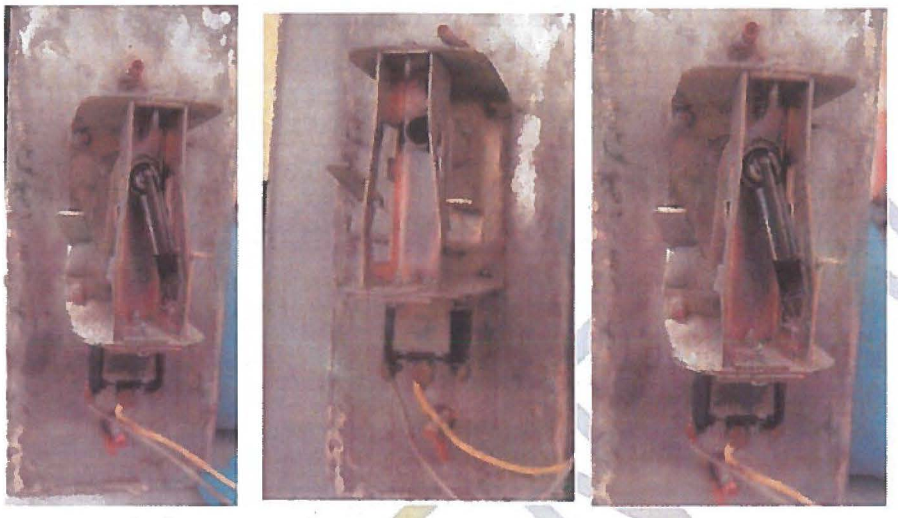
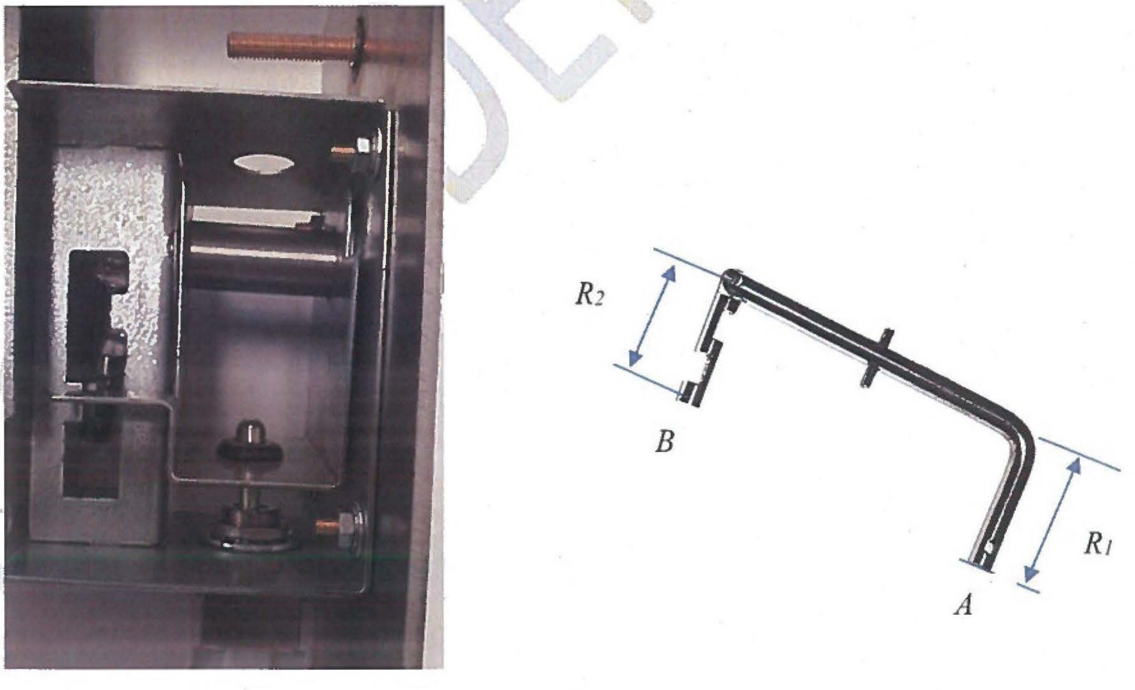


Figure 2. 'Fire Control' switch with deformed frame elements [2].

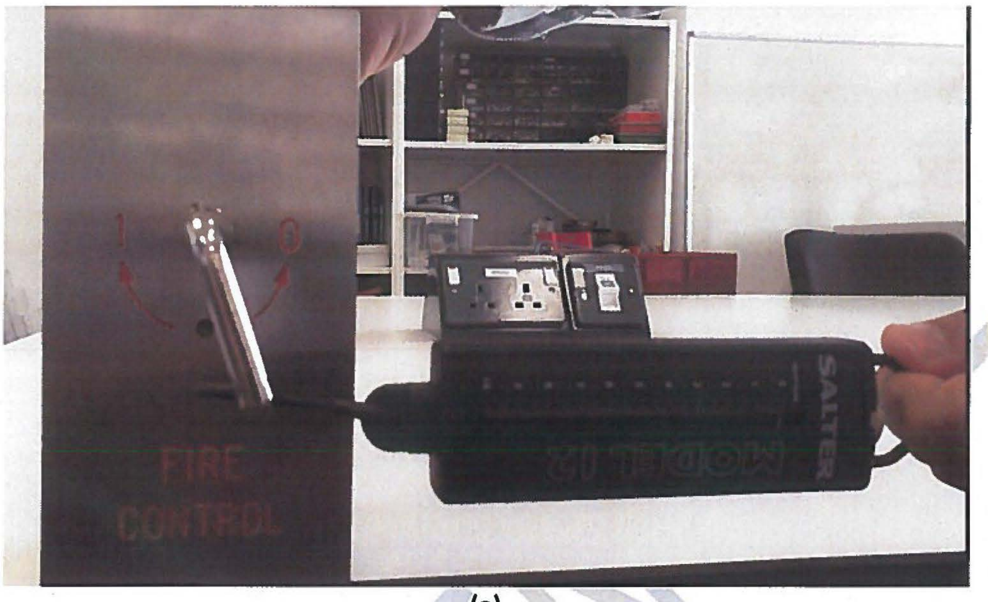


(a) **(b)**

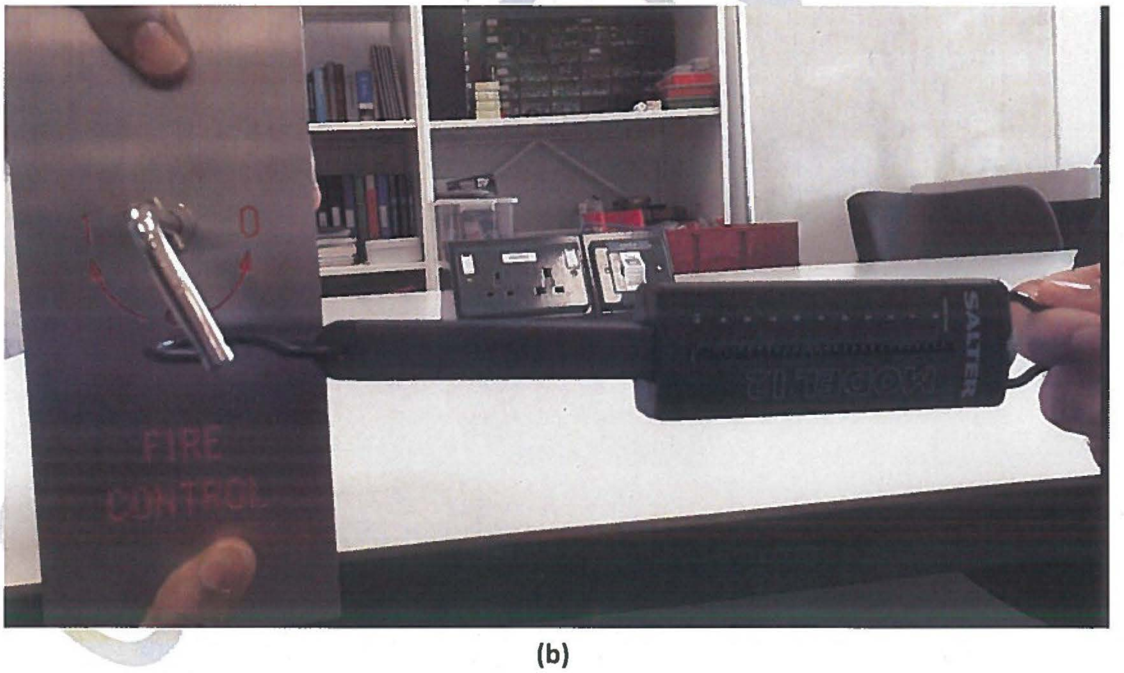
Figure 3. Control switch: (a) case and (b) 'drop key'.

EXPERIMENTAL TESTS

1. **Experimental procedure to determine the force required to operate the switch**



(a)



(b)

Figure 4. Experimental setup used to determine the force required to operate the switch

Salter Brecknell (Model 12) Spring Balance was used to determine the force required to operate the switch. Figure 4 (a) (b) illustrates the measurement setup.

In addition, the measurement was repeat by a 'dead weight' experiment (see Figure 5).

Figure 5. Experiment with dead weights.

The force used to operate the switch was measured to be 10.5 N.

2. Experimental procedure to determine the force required to bend the back box frame plate and bend / break the Express drop key.

The second test involved the setup illustrated in Figure 6. In this setup the switch was clamped in a workshop vice with the drop key operated by a torque wrench (Kennedy 3/8" SQ Torque Wrench [3]). With the drop key bottom end point engaged with the plate the torque was recorded and the bending displacements measured (see Figure 6,7). The torque values were then transposed to calculate the forces involved.

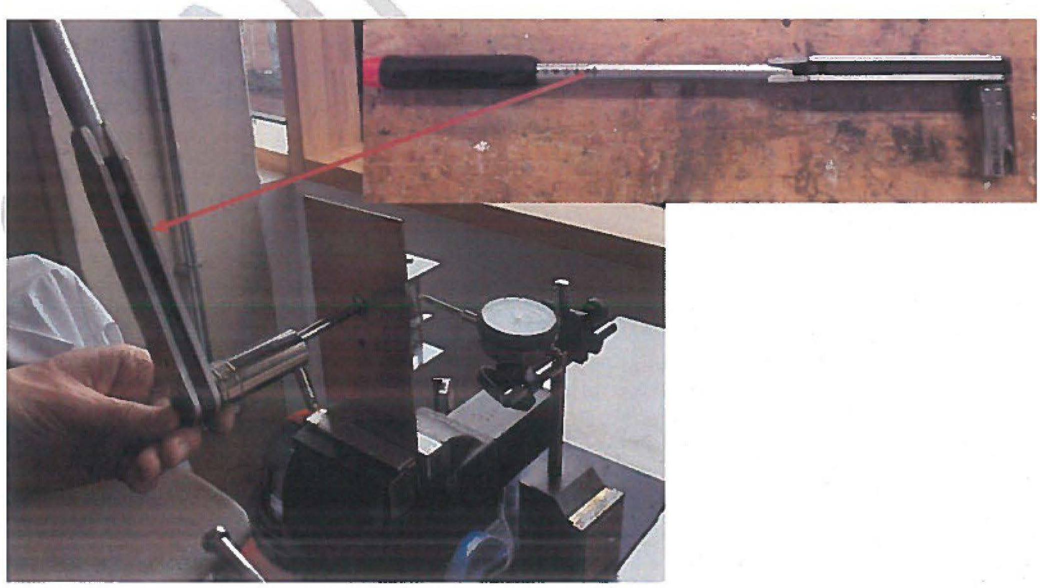
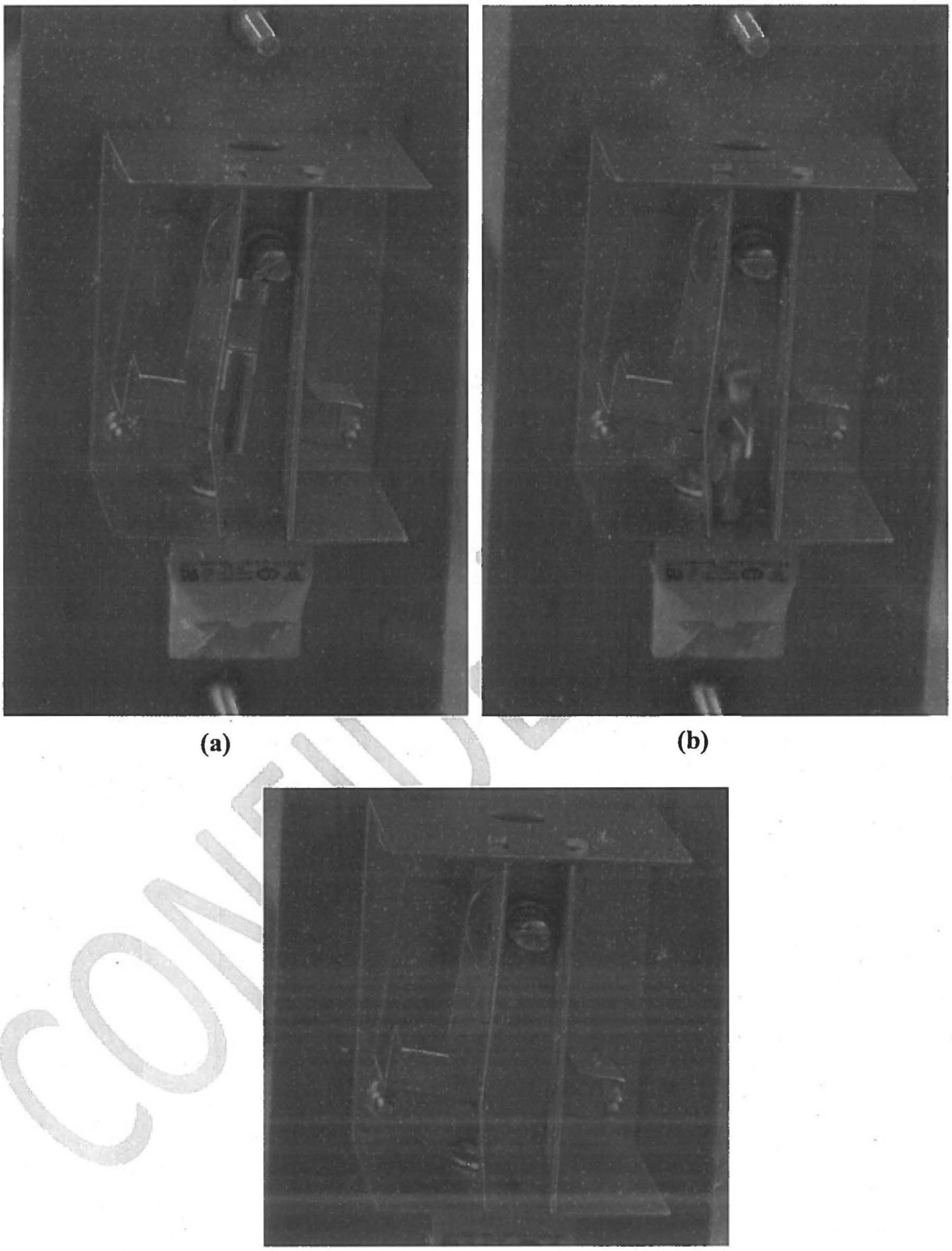


Figure 6. Torque wrench test setup.



(a) (b)

(c)

Figure 7. Test procedure: (a) the drop key bent at the hinge end; (b) breaking point; (c) with the drop key broken at the hinge.

The torques measured were 12 Nm and 14 NM, corresponding to the force values of 266.7 N and 311.1 N, respectively. The maximum displacements of the plate recorded were 1.76 mm and 2.08 mm respectively (see Table 1). Video evidence is available to confirm and illustrate the test procedures applied.

Table 1.

Torque measured *T* **[Nm]**	**Corresponding force calculated as** $F = T/R_1$ **[N]** $R_1 = 0.045$ **[m]**	**Displacement [mm]**
12	266.7	1.76
14	311.1	2.08

FINITE ELEMENT SIMULATION TESTS

A simplified CAD model and Finite Element Analysis (FEA) were developed to calculate the bending displacements of the the steel frame element under the loads measured. The results are summarised in Table 2 and the model is illustrated in Figure 8.

In the simulations a point force F_c corresponding to the torque of 12 Nm (determined as $F_c = T/R_2$ 12 Nm/0.035 m = 342.857 N) has been applied at various locations near the area where the drop key may get in contact with the 'cheeks' on either side of the entered key (see the images provided in the Appendix). Neither material properties nor the exact CAD models of the control switch structure were available. Therefore, the simulations were carried out for typical steel material parameter values (Young's modulus *E* and Poisson ratio ν).

Table 2

E **[GPa]**	**200 GPa**			**215 GPa**		
ν	**0.3**			**0.3**		
Load location	1	2	3	1	2	3
Deflection [mm]	1.009	1.528	1.616	1.022	1.422	1.502

The results demonstrate that the bending deflections calculated from the FEM model are close to the measured values.

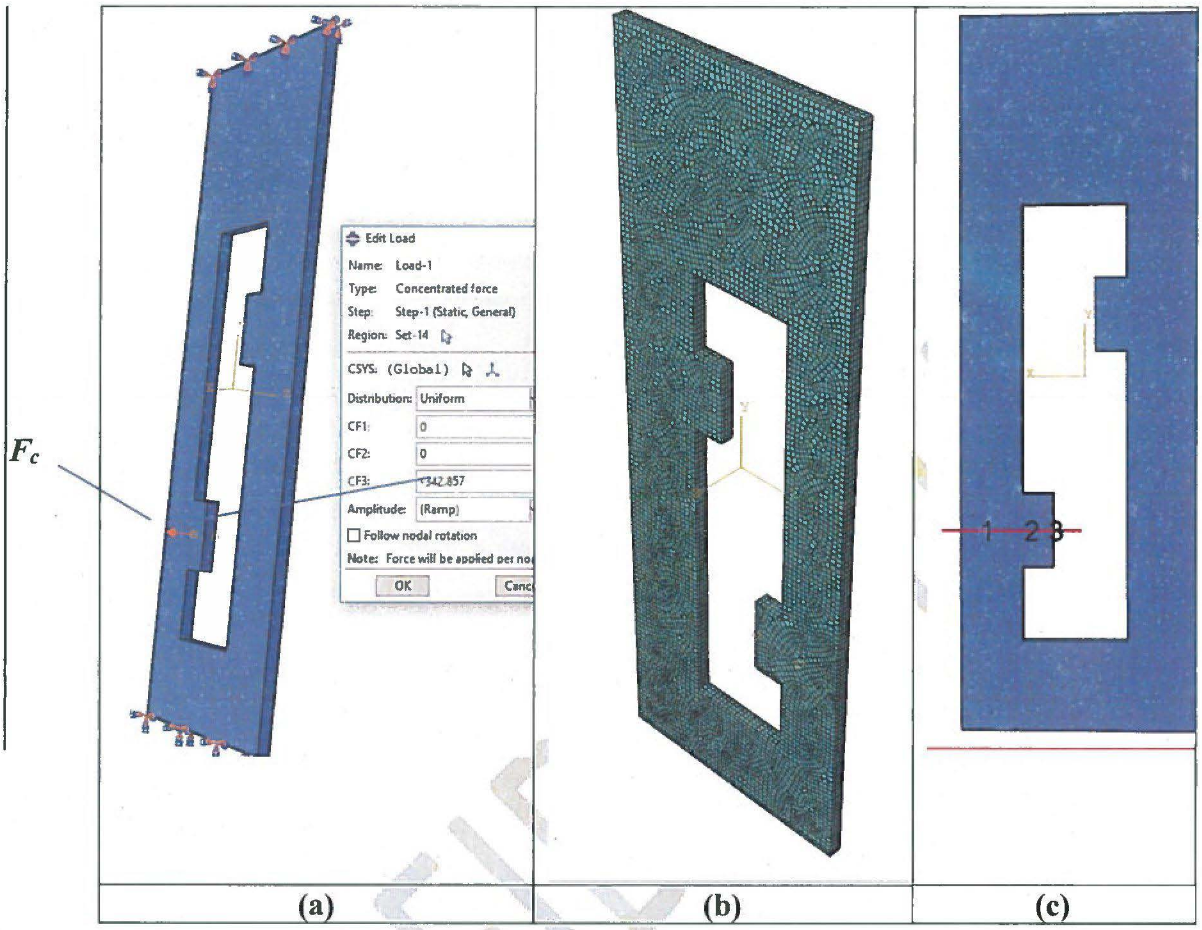


Figure 8. FEM model: (a) boundary and load conditions; (b) FEM mesh applied; (c) load locations.

SUMMARY AND CONCLUSION

The investigation carried out has led to the results summarized as follows:

- The force used to operate the switch was measured to be 10.5 N.
- The force to bend the switch frames depends on where the drop key hits the 'cheeks'.
- The maximum deflection will occur at the point of application of the load.
- The maximum deflection measured was approx. 1.76 mm. This value corresponds to the key turning torque of 12 Nm. This torque when transposed to a point force acting at point A of the key (see Figure 3(b)) gives the force of 266.7 N.
- The torque applied to bend the drop key and to break the key near the hinge was 14 Nm. When this value is transposed to a point force acting at point A of the key the result is 311.1 N.
- The FEM simulation tests were carried out to verify the measured values. An approximate/ simplified FEM model was applied.
- In this model the frame structure at one side of the drop key was represented by a constrained steel plate with a "labyrinth".

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- The results obtained from the computer simulation tests are within the range of the measured values.

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ACKNOWLEDGEMENTS

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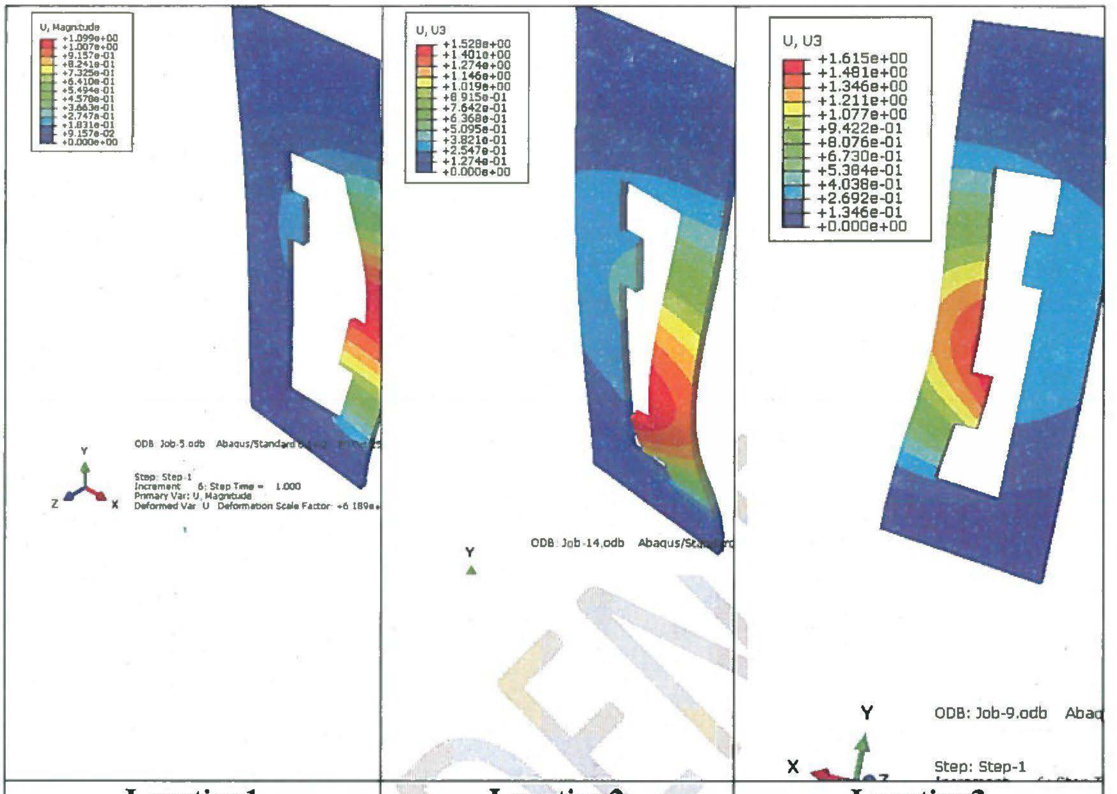
REFERENCES

[1] British Standards Institution, *Safety rules for the construction and installation of lifts - Particular applications for passenger and goods passenger lifts Part 72: Firefighters lifts.* BSI Standards Publication. BS EN 81-72:2015.

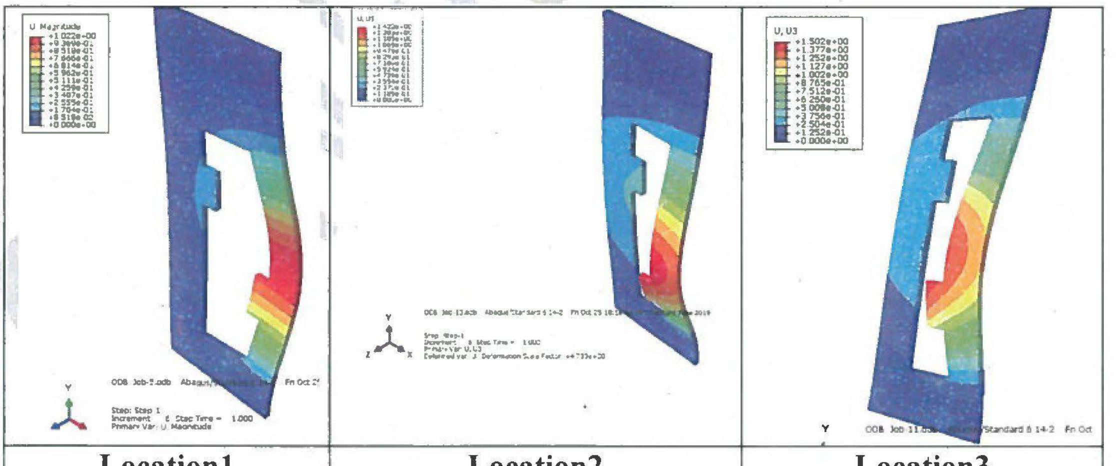
[2] R. Howkins, *Project Blue 2 - Testing of fire control Switch – Confidential.* ARUP Consultant/Vertical Transportation, e-mail communication dated 21 May 2019.

[3] https://www.bukalapak.com/p/industrial/tools/1ayyrri-jual-kennedy-3-per-8-inc-sq-dr-mechanics-torque-wrench-12-68nm-code-ken5570440k (accessed 24 October 2019)

APPENDIX



Location1	Location2	Location3
	E=200GPa	



Location1	Location2	Location3
	E=215GPa	