Experimental Studies on Guide Rail Fastening System

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Abstract. Lift systems consist of many components that must have high strength and a high factor of safety. Rail brackets and steel clips are used for fixing guide rails to shaft walls, sustaining the loads and providing linearity for the guide rails; they are essential elements of the complete rail fastening system.

In this study, in order to determine the loads to the bolts and clips complete rail fastening systems were designed. Stresses and deformations occurring in the guide rails, brackets, steel clips, and bolts are examined by experiments carried out. Results are interpreted with respect to the complete rail fastening system. The experimental results for clips and bolts and their impact on the complete system are interpreted separately.

1 INTRODUCTION

With the increase of urbanization and high-rise buildings, the importance of lifts has increased in our daily lives and lifts have become an essential which are used for vertical transportation. In terms of providing safe and comfortable travel guide rails and their fastening systems used in lift installations. Rail brackets and steel clips are used for fixing guide rails to shaft walls, and provide the linearity of the guide rails. These are the main elements of the complete rail fastening system. The basic functions of the guide rails and rail fasteners are to guide the car and counterweight during their vertical travel, and to minimize the horizontal movement of the car as much as possible, and to prevent tilting of the car due to eccentric load. Besides they provide safe stance and to stop the car by means of safety gear which is activated in case of emergency. Forces occur during the lift car travel and in the event of activation of safety gear on the guide rails and rail fasteners.

Previous studies are generally stress and deflection analysis of guide rails [1]. Studies about brackets and steel clips were limited in the literature [1-7]. In this study, stresses and deformations occurring on the guide rails, brackets, bolts and steel clips, are examined by experiments carried out in the laboratory and the results are interpreted.

2 GUIDE RAILS, AND RELATED EQUIPMENT

The guide rail is one of the important components of the lift installation. It must have strong structure, because it bears all the loads and forces of lift. Guide rails are used to guide the vertical movement of the car and counterweight separately, and minimize their horizontal movement [1-3]. In this study T 90 B type of guide rail were used.

Brackets are used as auxiliary elements in terms of provide linearity of guide rails which connect the guide rail to the wall. These brackets must have enough strength to prevent horizontal movement of the rails. Metric bolts used on the brackets are as important as others. They sustain the same forces and loads as the guide rails brackets. For this reason, bolts occupy an important place, because these small parts bear all the loads and forces of the lift.

Clips are used for fastening guide rails and brackets. They have a different structure and dimensions, compared to the bolts. They are manufactured with aid of the casting, because of their structure. In this study T3 type of clips were used. British Standard BS A305 taken for bolt about tensile and shear testing system, and then it used to test for clips. Figure 1 shows how to anchor the guide rails and brackets to a wall [1-3].

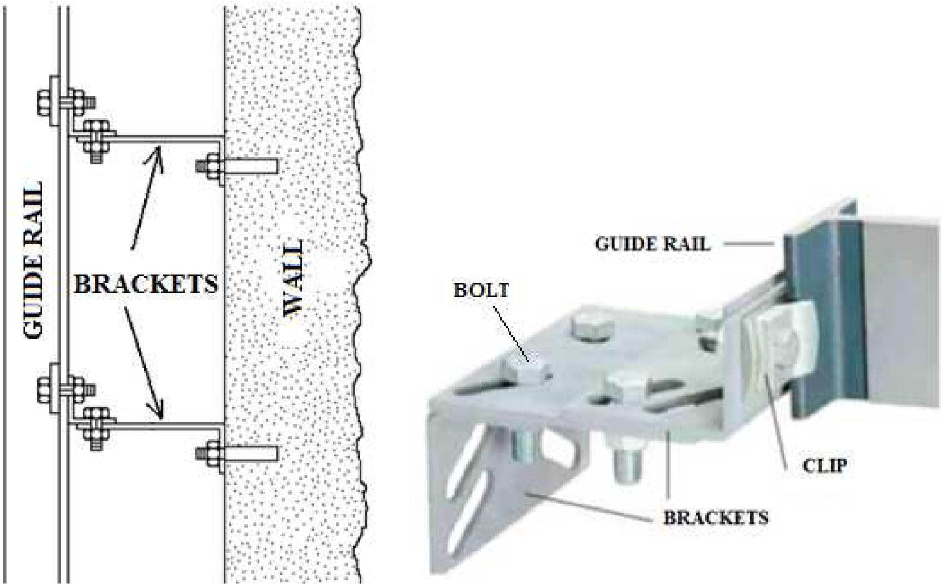
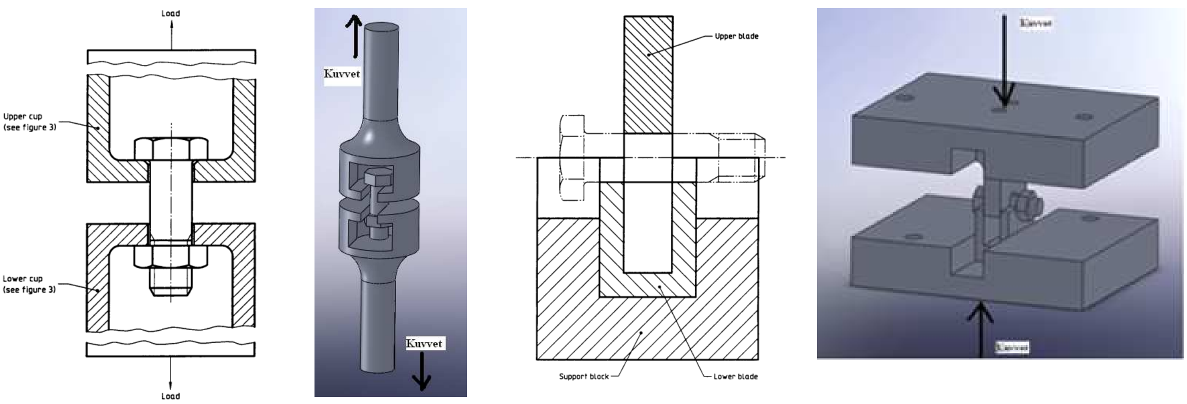


Figure 1: Assembly of guide rail, brackets with fasteners

3 TEST PROCEDURE OF FASTENERS

In this study, bolts and clips are used as fasteners. The equipment for the tensile test is modelled as cylindrical shape, taking into account the machining process. Besides this, heads of equipment are designed according to the grips of the machine. The slot part where bolts and clips are fixed is formed in a channel-shape. The tensile test apparatus, for bolts and clips is shown in Figure 2a. The load speed of the experiment is taken from standard BS A305. To perform tensile tests for a bolt and clips sample with 12 mm in diameter, the rate of load should be 80kN/min [4].

In order to perform shear test for bolts and clips, the test apparatus are proposed with three separate parts. These tests are made with pressing and this changed the structure. For this test, thicker materials are used for the bottom part and upper part which are connected to the test machine. The third parts as known connector, related to metric threat is modelled and machined separately. Figure 2.b shows the complete shear test apparatus. According to BS A305 to perform double shear test for bolts and clips 12 mm in diameter, the rate of load should be 160kN/min [4].



a) Tensile test apparatus b) Shear test apparatus

Figure 2: Test apparatus [5]

4 TEST PROCEDURE OF COMPLETE RAIL FASTENING SYSTEM

Throughout the service life of the structural system, designed not to break down under estimated load has critical importance complete rail fastening system analysis is fairly complex, but it is valuable design and design of modern structural systems. In the literature on this issue, particularly with respect to the complete rail fastening system, experimental studies are not in sufficient number and scope.

The brand new convenient test machine as shown in Figure 3 consists of four main groups which are carrier block that made by St37 materials and it was formed by welding construction. (1), a hydraulic actuator that provides applying variable loads (2), control units were used to perform to provide desired load combination to the system, sensors were used to arrange, measure and record to loads and displacements. This test machine that is supported by Turkish Lift Industrialists is under development. After developing PLC codes the tests will be conducted.

Experimental studies will be performed in Lift Technologies Laboratory (ITU). When setting up the experimental set up, the idea in comprehensive paper of Dr. Merz from HILTI Company was examined and adapted for the test rig [6,7].

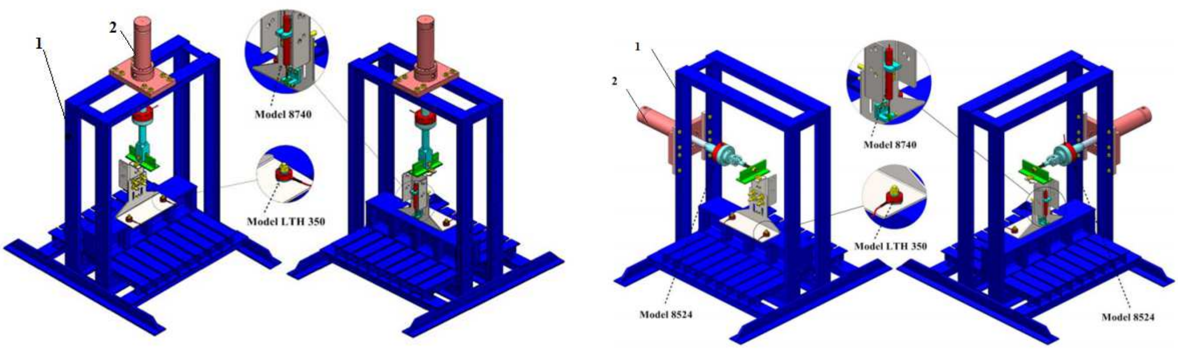


Figure 3: Experimental setup for complete rail system with vertical and horizontal installation [2]

In this test machine metric bolts and clips will be used for variety of guide rails. There are two types of sensor used in the experiment load measurement sensors and displacement sensors.

Fasteners can make displacement or relative motion under load. In order to prevent from these movements bracket's bolts are assembled with preload. Namely, by applying the force (F), $\mu F_{preload}$ friction forces between the parts occur. Theoretical principle of fasteners is provided for making effective mechanical connections.

$$F_S = \mu F_{preload} \geq F/i \quad \text{or} \quad \mu F_{preload} = c_0 F / i \qquad (1)$$

where $F_{preload}$ is preload force, Fs is friction forces, i is number of bolts, i; $c_0 = 1{,}1 - 1{,}5$ is safety factor against to shear. From this equation the connection force can be calculated.

$$F_{\text{preload}} = \frac{c_0.F}{\mu.i} \qquad (2)$$

Additionally fasteners used in the guiding system were tested on the indoor test tower. The experimental set up was designed and established in order to examine the behaviour of different load cases. Designed experimental set up are given the opportunity to examine variety of guide rails and brackets more extensively in the future. With this design it is possible to apply tensile and compressive forces. Sensors and data collectors were assembled on guide rails fasteners. Real time data was obtained by examining the situation in different loads of the test car. Figure 4 shows the properties of test tower. Under different loading conditions of the lift car, the forces affecting the guide rails bracket and fasteners were examined. In these experiments, a test tower which is 7.3 meter in height was used.

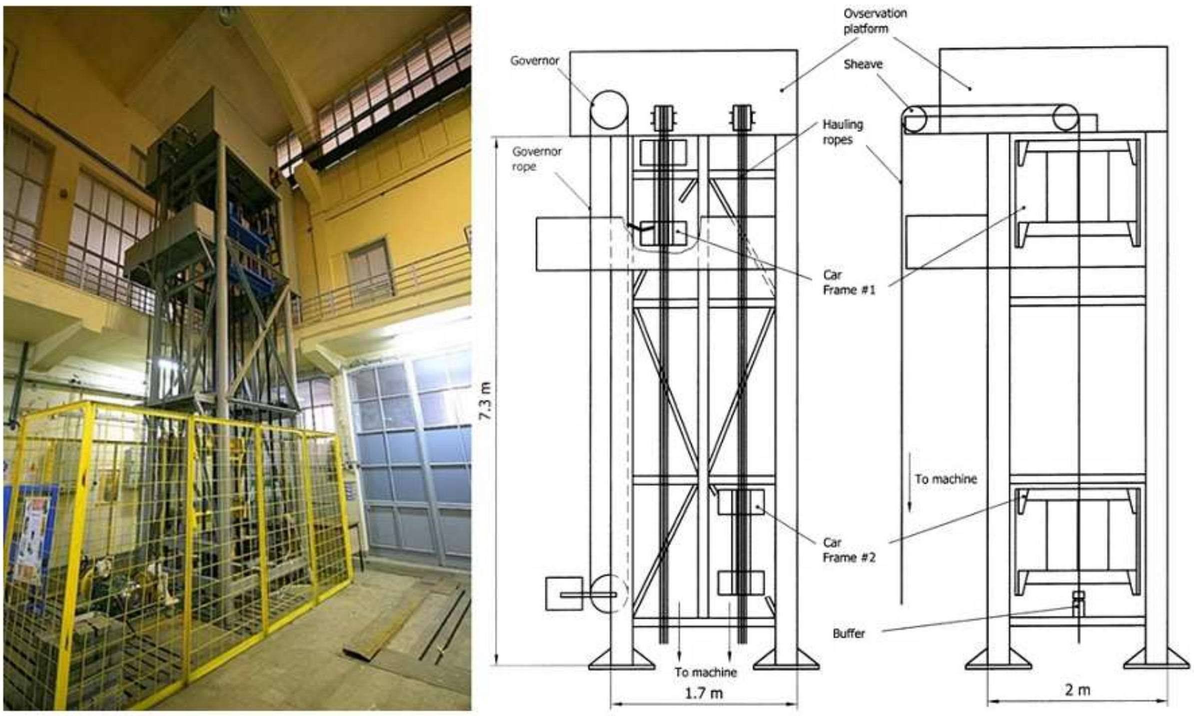


Figure 4: Indoor lift test tower [2]

USB data acquisition device (sensor interface), was used for transfer data from sensors (load cells) to computer. DigiVision software was utilized for the processing the data. This system has 16 bit resolution and it allows up to 2500 measurements per second (See Figure 5).

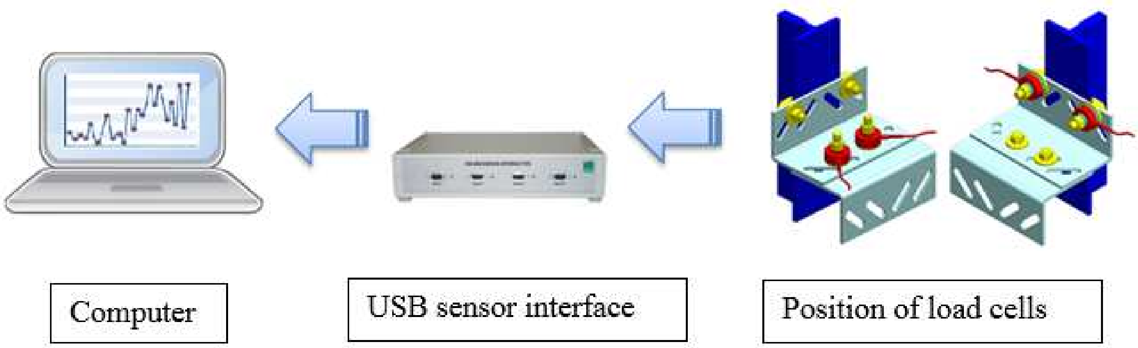
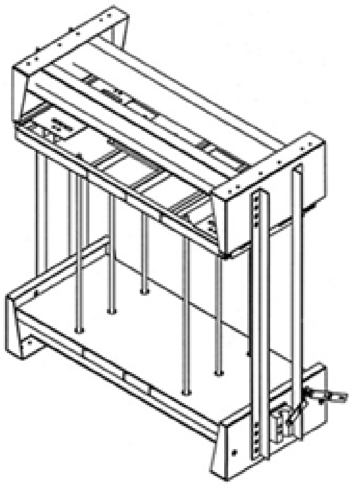


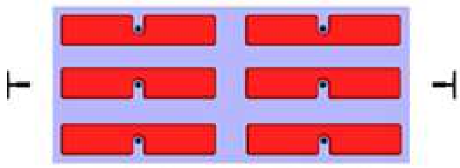
Figure 5: Data acquisition and signal processing [2]

In this study, stress and compression load cells and donut shape load cells were connected to the fasteners (See Figure 6). Donut shape load cells were used in order to investigate the compression load on the bolts.

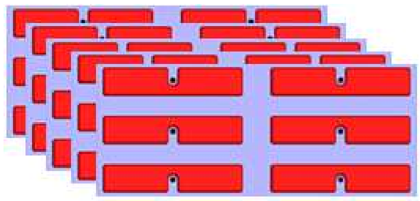
Figure 6: Donut shape load cells installation [2]

In this test car for 8 people, empty and loaded (%100 full) cases were investigated. Steel casting weights (each 17.3 kg) were used to ensure that the car frame empty and loaded cases. Each of them 17.3 kg steel casting weights were used for providing car empty and loaded cases (See Figure 7).





Empty case: 10 pieces of steel casting weights

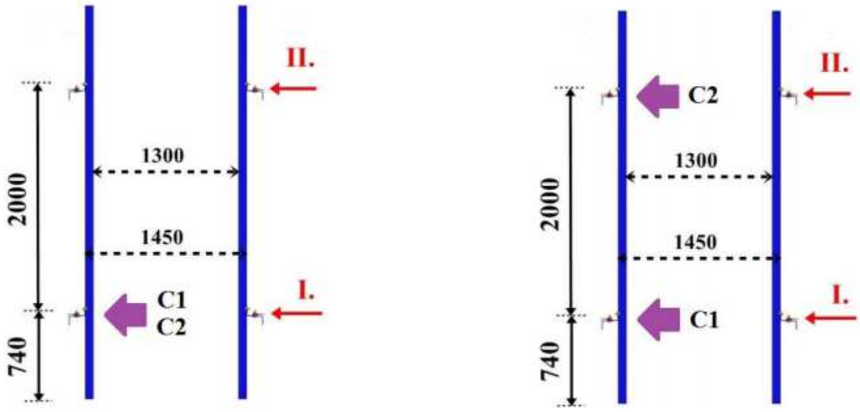


Loaded case: 46 pieces of steel casting weights

Figure 7: Different load condition of lift car

T90 / B type standard guide rail was used for guiding the test cars. Guide rails assembled from 4 points and the distance between brackets on the guide rails was 2000 mm. Different test condition and configuration can be seen from Figure 8.

In Figure 8 the donut shape load cells are depicted with C1 and C2. In the Test 1 condition, load cells are placed on the same bracket. In the Test 2 condition C1 and C2 load cells are placed separately on a lower bracket and upper bracket.



Test 1 Test 2

Figure 8: Two different test configurations

In this study, bolts and clips which are used as fasteners for anchoring the guiding system are examined under certain loads experimentally. The experimental set up can be seen from Figure 2. It is observed from experiments result, that the shear test value is negligible compared with the tensile tests. Each experiment was performed 5 times and observed each experiment has given close values. Tensile test results for bolts and clips can be seen from Table 1 and Table 2 respectively.

Table 1: Test result for bolts 12 mm in diameter

Test number	Yield point kN
1	46.1898
2	47.4258
3	47.1053
4	45.4344
5	47,8149

Table 2: Test result for clips 12 mm in diameter

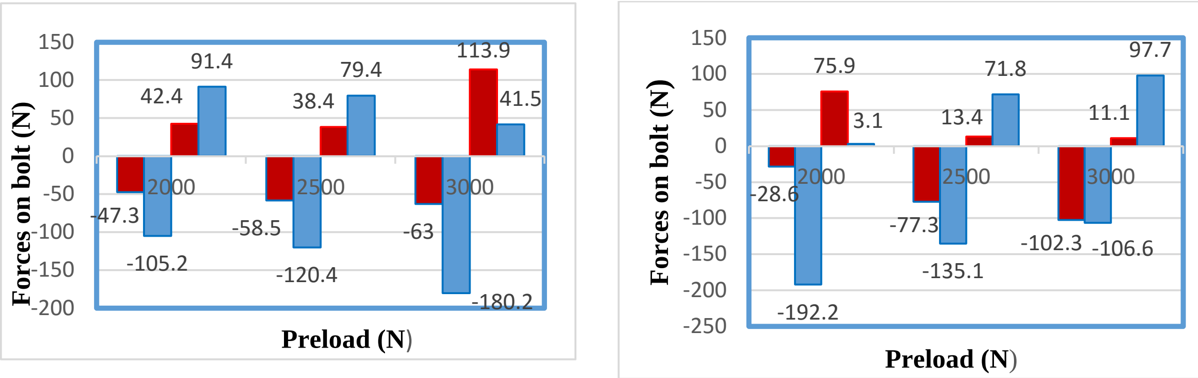
Test number	Yield point kN
1	32.8684
2	34.1044
3	35.5922
4	37.0342
5	36.8053

The bolts are tightened with three different preload conditions: 2000, 2500, and 3000 N. The zero point was calibrated in accordance with these preloads. The forces under the preload were negative, the above values were positive.

The following forces on guide rails shall be taken in account for the case of safety gear operation with different load distributions:

The horizontal forces from the guide shoes due to masses of the car and its rated load, travelling cables, etc. taking into consideration their suspension points and dynamic impact factors. The vertical forces are from the braking forces of the safety gears; weight of guide rail, and □push through forces of rail clips. The vertical load is carried by the rail itself and partially by the brackets whenever the guide rail is not fixed at the pit.

The first set of tests was performed for empty car condition for Test 1 and Test 2 load cell positions. The results from Test 1 and Test 2 load cell conditions are shown in Figure 9. In the graphs the red bars and blue bars depict the maximum and minimum data that are collected from C1 and C2 sensors respectively. X axis shows the preload conditions 2000, 2500, and 3000 N.

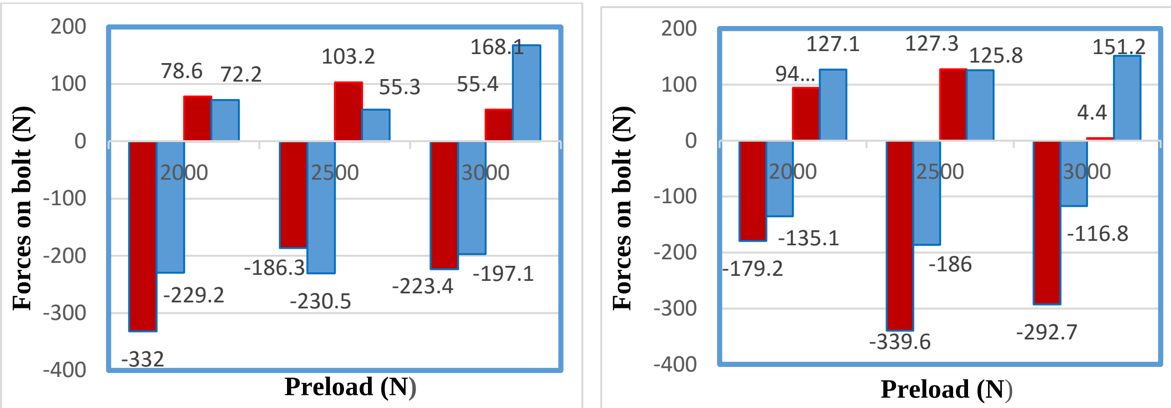


Test 1

Test 2

Figure 9: Forces on bolts empty car [N]

The second set of tests was performed for fully loaded car condition for Test 1 and Test 2 load cell positions. The results from Test 1 and Test 2 load cell conditions are shown in Figure 10.



Test 1

Test 2

Figure 10: Forces on bolts loaded car [N]

5 CONCLUSION AND DISCUSSION

In this study, T90/B guide rail and its fastening elements are examined experimentally. The forces exposed to the clips and brackets during operation was measured and recorded. According to the test results maximum force is in (C1 sensor, 3000N preload) for fully loaded car condition, was measured as -328,9 N. According to individual tests for bolts the yield point was measured around 47 kN and for clips it was measured around 36 kN. Whereas the tests conducted on the complete fastening system allowed for the performance of the entire system under various preload and assembly conditions to be assessed. Additionally, on unique test machine for bracket and fasteners designed and built. After adapting hydraulic driving and operation codes via PLC test results will be reported.

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BIOGRAPHICAL DETAILS

Suhan Atay Mr. Atay received the BSc degree in Mechanical Engineering from ITU in 1995 and MSc degree in Mechanical Design from ITU in 2013. He is working as a Design Engineer.

Ozlem Salman has been employed as a research assistant in ITU since 2009. Mrs. Salman received the BSc degree in Mechanical Education from Faculty of Technical Education Marmara University in 2008 and MSc degree in Mechanical Engineering from ITU in 2010. She has carried out research into PhD thesis.

C. Erdem Imrak has been employed as a fulltime Professor in ITU. Prof. Imrak received the BSc, MSc, and PhD degrees in Mechanical Engineering from ITU in 1990, 1992, and 1996 respectively. He has carried out research into materials handling and especially lift systems. Currently his activities include: a Member of the IAEE; a Member of the OIPEEC; a Member of Chamber of Mechanical Engineers in Turkey; a Member of Steering & Consulting Committee of Asansor Dunyası Magazine and a Member of International Committee of Elevatori and Rapporteur from Turkey.