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Restoration and Strengthening of a Historical Structure in Antalya - Turkey

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Abstract Protection and restoration of historical structure has a big importance to transfer past from future. It is necessary to protect all materials and documents that includes past culture, life style and life art in purpose of human history. Structures that used in past, is most important of these materials. Protection of historical structures that reflect to history of period and is historical artifact is also important because of emphasized reason.

There are many historical structures in different region of Turkey. Some structuring especially show all cultural structure of that period and stand erect as grand monument. But in the length of time these type structures abrade and lose their nature, because of natural or other reason. After ever earthquake, almost each historical structures have permanent damages in Turkey which is earthquake area. For this reason, It is necessary to transfer future these historical structures by strength and repairing to discover local earth conditions and equipments that used in structure against to earthquake and other affects, determining damaged condition, determining system of architecture and conveyer to these historical structures On the other side, protection of structure can be provided with help of increasing functionality. Unused and closed historical structure will abrade and because of natural and other affects, it will damages and becomes unused. So, basic protection is to use and repair periodically to these historical structures.

In near future, protection and restoration of historical structures get importance in Turkey. Many historical structures start to handle for this propose, works pick up speed for restorations. Mustafa Kemal primary school which used as school long time, and completed construction in 1910 Antalya-Turkey, is other important cultural heritage. Accumulation school building has basement, ground floor, and 1.floor. Because of floor height, basement has not been used. Other two floors have been used for common room, laboratory and toilet. In this work, after building survey of historical building used for school had been taken, equipment used in building had been confirmed and local earth condition had been determined, according to exist Turkish Regulations building analyze had been done. According to lacks of structure, it had been invigorated. For propose of implementation of architecture style to period, all added parts had been restored and renewed to damaged parts.
Keywords: Restoration, strengthening, historical structure

Introduction

Prerequisite for protection of historical structure is reparation without breaking of historical means of structure. Because all equipments used in building is symbol of that period, it give less harm that using of same equipments in it reparation or intervention must be minimum. Extant many historical structure or monument get harm in every phase that put over because of some external factors such as; earthquake, fire, natural disaster, abrasion. It is important that how stick to periodically restored this structures and monuments and whether added parts and equipments is wrong or true, when structures renew and invigorates, or intervention on structures For this reason, original shape of structure must be researched and getting certain information about historical and architecture specialties of structure have to be known, before intervention is not started. On the other side, because each structure and architecture has own specialties, it must be determined to shape of restoration related with that structure while structure is renewed.

At the present day we can see many samples of these structures and monuments. Although renewing style is not same in many structures, it shows similarities. Due to this, differences, shape

and renewing of style of buildings considerably is various. But methodology that discussed in these researches is almost same. These researches show us way. Generally it is possible to separate these studies into 3 parts. First of all is to determine equipments that will be used in structure, second one is to model structure, third one is renewing and invention. 1997 Karaveziroğlu, Barboutis and Karanas researched that impact of brick and daub that used in historical structures on inlay wall resistance. Wall characteristics of Di Pasquale' 1997 Santa Maria Del Fiore Cathedral had been determined with experimental studies, and canopy of cathedral had been explicated. Lourenço ve Rots' 1997, Lourenço' 2002 researched that pile walls resistance and values of carriage power with experimental and hypothetical studies. Ahunbay' 1988 analyzed that techniques of build up and used equipments in Mimar Sinan structures. Aköz ve Yüzer'1995 and Özşen and diğ.' 1995 researched that used equipments and constructive breaks on Small Ayasofya Mosque with experimentally and its own place. Anand ve Yalananchili' 1996 had analyzed composite pile walls, and characteristic resistance of equipments that used on Ayasofya Mosque had been determined by Erdik, Yüzügüllü and Karakoç' 1990, Çakmak, Mark and Erdik' 1992, Erdik and Durukal' 1993. Bozinovski and Velkov' 1983 had made equipment experiment on two historical pile structures.

Reparation and renewing of Çin-Pagoda had been done by Pichard', Gavrilovic' 1993 had renewed and did invention historical structure in Üsküp. Koçak' 1999 had confirmed constructive harms with modeling method of finite elements in historical Small Ayasofya Mosque.

History of the building and properties of the structure

According to Çimrin 2005, structures named as "NEFİSE (ART) MEKTEBİ" had opened in 1906 Antalya Merkez Elmalı Hometown and it had been education center for big part of city. According to other view, suggested that school had been finished by Mr Mimar Kemalettin in 1905. Structure had get name of " GAZİ MUSTAFA KEMAL İLKOKULU " in 1926 and it has served as educational association until end of 2005. But during Italian occupation in 1919, school had suspended education and it had been used as camp and arsenal by Italian.

When Tablet that found by cleaning of grout and paints of limra tablets that is size 68*123 cm in east entrance of structure has been analyzed by Antalya Museum Experts, article of "1951 (1331 R) date and İTTİHAT AND TERAKKİ MEKTEBİ" had been read. It has not been determined that this articles that tried to understand of meaning was put on during built up period. According to other view, it suggested that it built up by Sabur Paşa by using "Worker Tabors" troops of that period. Moreover, it has been determined that Nefise (art) school was not exist in that period.

Structure that made to aim of school has U plan, also it has two stairs that only come up to upper floor into middle axe and, come up to ground floor and entresol due to height differences. Inside of U plan has shape of court. It comes up ground floor with 7 unit block limra stone and there is limra doorjamb door in main entrance. Structure transformed to rectangle from U shape by adding concrete floors, column, and beam with aim of added classroom.

Main walls are 85 cm in the rocky area. All walls had made with local cliff stones. Daub which includes lime, sand, and chaff had been used as binding. In concur grouts inside and outside of structure drew up with daub used on walls, because of cement based grout, original grout was distorted.

It has been determined that covering has been built up with all walls had been framed with wood planks at floor level and sketch that nearly size is 650 cm and 14x22 cm was put on wood planks, nervures from cedar broad 35-40 cm discrete. Moreover, wood planks framed to wall in top of door height (305 cm). So, it has been provided that wall of structure body lock in top of door and covering as plank. All cedar wood manufacturing was bonded with hot steel forging nails.

Roof of structure was built up with system of hanging roof that was 610 m out from mesh timber. In size of 12x18, 18x22 and 12x15 cm timber was used in manufacturing. Scissors gap is nearly 160-170 cm. There are rafters in size of 5x9 cm between scissors and 2.5x10cm covering under tile on it. All woods are good and usable regardless of board of covering under tile. Measured drawing and section of structure has been shown on Fig. 1 and Fig. 2. ground floor of structure has been used for well and water needs of structure has been provided here.

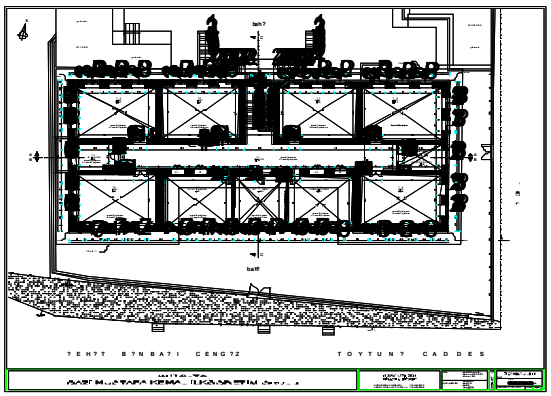

Figure 1: Measured Drawing of Structure

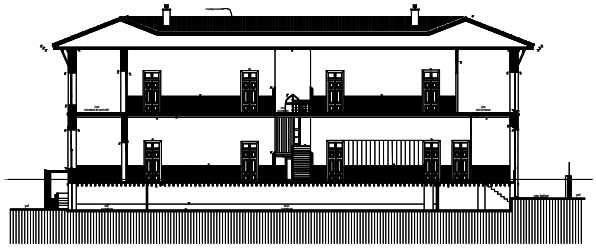

Figure 2: Section of existing situation of built

Result of burning next wood house, fire had started into school in 1989. it has been determined that ground floor and first floor of room in north west corner completely had burned, and some part of corridor and roof paneling and coating of the same room had burned also. After fire in 1989, wood beams have been consolidated and floor coating had been renewed. Fire and construction work that made after, get many harm to original of structure. It has been determined that was made first thin grout after grained paint on grout that occurred from sand, chaff and lime, almost whole doorjambs and floors was broached or broken, locked stairs that made by cutting from limra stone, first was lay over bulk mosaic and after wood.

Moreover it has been observed that west, east and south balconies was fell down, and reinforced concrete stairs was made instead of it, some part of ground floor windows was closed with brick., original roof covering and garden walls was changed.

The biggest harm that made, is transforming of U plan to rectangle by structure up annex 1 floor that is reinforced concrete onto ground floor. Even though reinforced concrete construction put onto columns, it was determined that all windows and balcony doors that U plan involved, stayed into conveyer brick walls by applying mixed system in upper floor. (Fig. 3)

Figure 3: Picture of existing situation of structure

Analyzes and investigation on structure

According to existent Earthquake Regulation of structure that taken measured drawing, investigation was done, all architectural details of structure that want to use as governor's office, has thought, and timely disappeared historical structure and aesthetic also has get attention in new plans. The purpose of determining of earthquake safety, structure has been modeled with Sap2000 program, result of modeling, strength projects has been prepared to structure that determined lacks for possible earthquake and vertical loads. Before structure analyzes, equipments related with building and local earth conditions has been analyzed. Analyzes and estimations has been made accordance with Turk Earthquake Regulations 2007. Some part of regulation that used in this work about "Pile Builds Design Rules" as below;

a) Spectrum value in situation that need make earthquake estimation $S(T_1) = 2,5$ and coefficient of decreasing to earthquake load $R_a(T_1) = 2,0$ must be taken

b) According to Table 1 limitations has done about floor heights. In this table, emphasized numbers of floor are cumulative of ground floor and full upper floors.

Table 1: Allowed maximum numbers of floor

Earthquake area	*Maximum numbers of floor*
1	2
2,3	3
4	4

d) Limitation of floor height in pile buildings, maximum is 3,0 m through from floor to floor. r.

e) Conveyer walls of pile buildings must be edited nearest to symmetric or symmetric according to main axis in plan as systematic as possible. Whole conveyer walls that made continuously must go on from upper floor to lower floor.

f) Natural stone, full brick, as pile equipments in conveyer walls, block bricks and bricks that keep biggest emptiness rate and as allowed conveyer wall equipment in TS- 2510 and TS EN 771-1, structure and equipments of gas concrete, lime sandstone, full concrete briquette, mud brick or similar kargir units can be used. Natural stone conveyer walls only can be built up in ground floor and basement. Concrete conveyers that used in structure only can be used in ground floors.

g) Lowest compress strength of natural and artificial masonry units that will be used in conveyer walls must be at least 5.0 Mpa according to gross compress area. Compress strength of natural stones that will be used in ground floor must be at least 10.0 Mpa. In situation that builds up concrete walls in ground floor, lowest concrete quality must be C16.

Characteristics of structure equipments

Result of laboratory with explained experiments that were destructive and nondestructive in F.Aköz and N.Yüzer 1995, characteristics of local cliff stone that used in structure has been defined. Destructive method (core) and nondestructive methods (ultrasound, schmidt hammer experiments) has been used. Result of measurements, correlation has been done between determined destructive and nondestructive compress strength. Correlation between Voice pass speed (V) and surface asperity (R_{min}) has been determined as below.

For cliff stone

$$f_{teo} = e^{1.778+0.005(R\times V)} \quad (r = 0.921) \tag{1}$$

It has been confirmed that grout had impact to deceive strength of grouted stone elements and it lost force of conveyer of structure somewhat over to daub strength (Koçak, 1999). Grouted filler walls have been taken as one element in model and result has been compared with experimental models. It has been taken in model as Cohesion (c) value 3,5 Mpa, frictional angle (Φ) value 35°.

Compress and bending strength are given below on average for masonary structure wall related with some experiments in literature.

Compress strength

2.0 – 10.5 Mpa (UNIDO, 1984)
3.0 – 12.0 Mpa (VSL, 1990)
1.5 Mpa (ATC, 1978)
1.5 – 2.5 %20 of stone strength or Mpa (Sheppard, 1985)
2.2 – 3.5 Mpa (daub value, Penelis and others)
11 – 15 Mpa (brick value, Penelis and others)

Bending Strength

0.1 – 0.3 Mpa (UNIDO, 1984)
0.2 – 0.6 Mpa (ATC,1978)
0.12 – 0.18 Mpa or 0.075 Fc (Sheppard and Tercely, 1985)

By the way of these examples and experiments, it has been defined as Compressive strength of stone is 20 Mpa, density of stone is 2.5 ton/m³. Rate of Poisson has been taken as 1/6. According to

statement of Turkish Earthquake Regulation, it has been determined as f_d=0.5x20=10 MPa, f_{em}=0.25x20=5 MPa, modulus of elasticity is E_d=200xf_d=2000 N/mm2. Determined values are close with literature values to upstairs.

Analyzing and modeling of structure

After determining of measured drawing of structure and creation of axes, structure has been modeled with method of finite element. Quad solid elements have been used for modeling of structure. Conveyer columns in front of building have been assigned in size of 30cm x 50cm as conveyer. All walls in level of floor have been circled with wood planks and floor covering has been modeled with in size of 14 x 22 cm 35-40 cm spaced nervure lumber and wood planks. Characteristics related with assignment of equipments that used in model have been shown on Table 2. 4659 element had been used in model such as;4293 unit quad solid element, 303 unit bar element, 57 unit covering element, 6 unit stair ramp. Numbers of Total crucial point is 17424. All elements have been improved and defined with prismatic elements accordance with characteristic of equipment and behave.

Table 2: Characteristics of equipments that used in model

Material Properties (ton - m)						
Equipment	*Type*	*Mass*	*Weight*	*E*	*Poisson*	*slip module*
Falez stone	Isotrope	0.25	2.50	204000.00	0.20	84976.35
Steel	Isotrope	0.80	8.00	21000000.00	0.30	8076923.08
Wood	Isotrope	0.08	0.80	1000000.00	0.30	384615.39

Pier has been assigned to 2277 units of defined 4293 solid elements related principle of program work. Piers are wall and vertical conveyer that has sustainability on program. We will have stress on wall with Assignment of piers. 2016 solid elements on doors and windows have been defined as spandrel. Other characteristics of definition have been given with Table 3 in order to compute earthquake force in model.

Table 3: Data that given program

Regulation	*2007*	*Height of floor*	
Earthquake area (Ao)	0.4		m
Coefficient of structure import (I)	1.5	Floor 3	4.71
S(T)	2.5	Floor 2	5.08
Conveyer system coefficient (R)	2	Floor 1	3.2
Coefficient	3		

After all assigned values entered, load combinations had been created to define load of dynamic, stable and earthquake related with structure. Total area of one floor in building is 637.78 m² at model. After this process, model had become ready to analyze. Model shape that created in program has shown on Fig. 4.

Computing of stress of structure wall

Stress values on wall that occurred with affect of Vertical load and earthquake force was shown on Table 4. In order to compute stress of slip on wall, loads that come from external load and earthquake force to structure has been computed with dividing section areas of related wall. Slipping values has been compared with computed values with equation (2).

$$\tau_{em} = \tau_0 + \mu \times \sigma \tag{2}$$

In this equation, τ_{em} = is wall slip allowable stress, τ_0 = is wall split allowable stress, μ = is Friction coefficient (as 0.5), σ is computed wall vertical stress. According to kind of masonry unit

that used on wall, wall split allowable stress (τ_0) has been taken as 0.1 Mpa for stone walls according to values into regulation. Slip stress on wall was shown on Table 4 for several point of wall. Insufficiency had been determined as shown on Table 4.

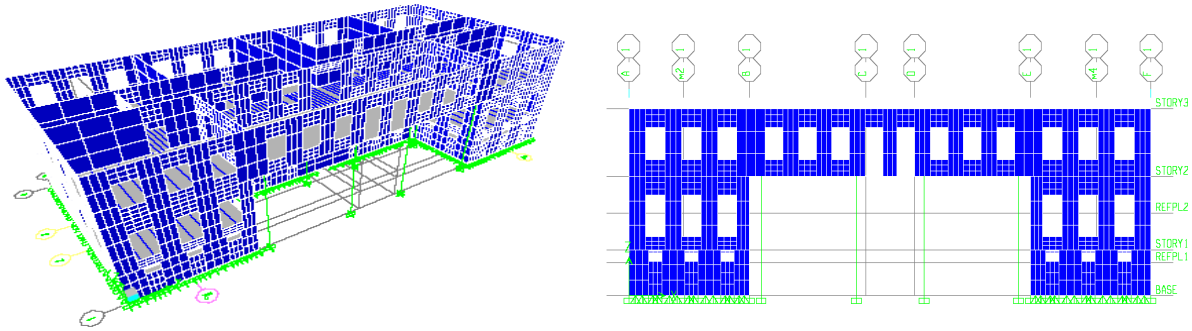

Figure 4: Structure that modeled in program

Table 4 – Slip Stresses and vertical stresses

RESULT OF ANTALYA GOVERNERS' OFFİCE BUILDING STATIC ANALYZE (Ton-m)												
Story	*Pier*	*P (G+Q)*	*V2EX*	*V2EY*	*V3EX*	*V3EY*	*V MAX*	*ALAN*	σ	σ_{em}	τ	τ_{em}
STORY3	P1	9.57	0.05	3.47	0.13	0.49	3.47	0.82	11.66	30.00	4.23	11.2
STORY2	P1	22.09	1.51	6.54	0.72	1.36	6.54	0.82	26.91	30.00	7.97	12.7
STORY1	P1	32.44	13.08	6.13	1.01	4.09	13.08	1.16	27.97	30.00	11.28	12.8
STORY3	P2	8.73	4.09	2.95	0.04	0.09	4.09	0.82	10.64	30.00	4.98	11.1
STORY2	P2	21.31	6.17	1.32	0.02	0.81	6.17	0.82	25.96	30.00	7.52	12.6
STORY1	P2	33.35	23.04	3.59	0.07	1.41	23.04	1.34	24.89	30.00	17.19	12.5
STORY3	P3	9.52	3.69	2.18	0.03	0.23	3.69	0.82	11.60	30.00	4.50	11.2
STORY2	P3	22.83	6.07	1.15	0.04	0.8	6.07	0.82	27.82	30.00	7.40	12.8
STORY1	P3	34.88	21.65	2.5	0.12	1.46	21.65	1.34	26.03	30.00	16.16	12.6
STORY3	P4	9.88	2.15	3.62	0.28	0.25	3.62	1.14	8.70	30.00	3.19	10.9
STORY2	P4	19.93	0.92	3.76	0.08	0.77	3.76	0.61	32.51	30.00	6.13	13.3
STORY1	P4	28.51	9.12	4.46	0.82	3.03	9.12	0.91	31.26	30.00	10.00	13.1

Strengthening and restoration of structure

According to Turkish Earthquake Regulation, insufficient structure has been strength with annex concrete and reinforcement mesh to increase cutting force and rigid of wall that succession showed sustainability from on the ground work to up. Moreover, the purpose of increasing of insufficient ground floor height, 2.00 m dig of groundwork has been done. Inorder to structure ground floor, ground height has been caved till 350 m included grounding thick in level of room wall, and dig groundwork of wall has been prepared with concrete shear wall to ad anchor anchorage to stone back ground. After this, dig has been cleared to complete shear wall of the same room one by one. Because structure of back ground has been hardest, operations had gone on for 8 month. After strength of ground floor, upper floors have been strength with same shape and accordance with computing. (Fig. 5)

Figure 5: Promoting to cave ground floor of building, Strengthing of ground floor and basement,

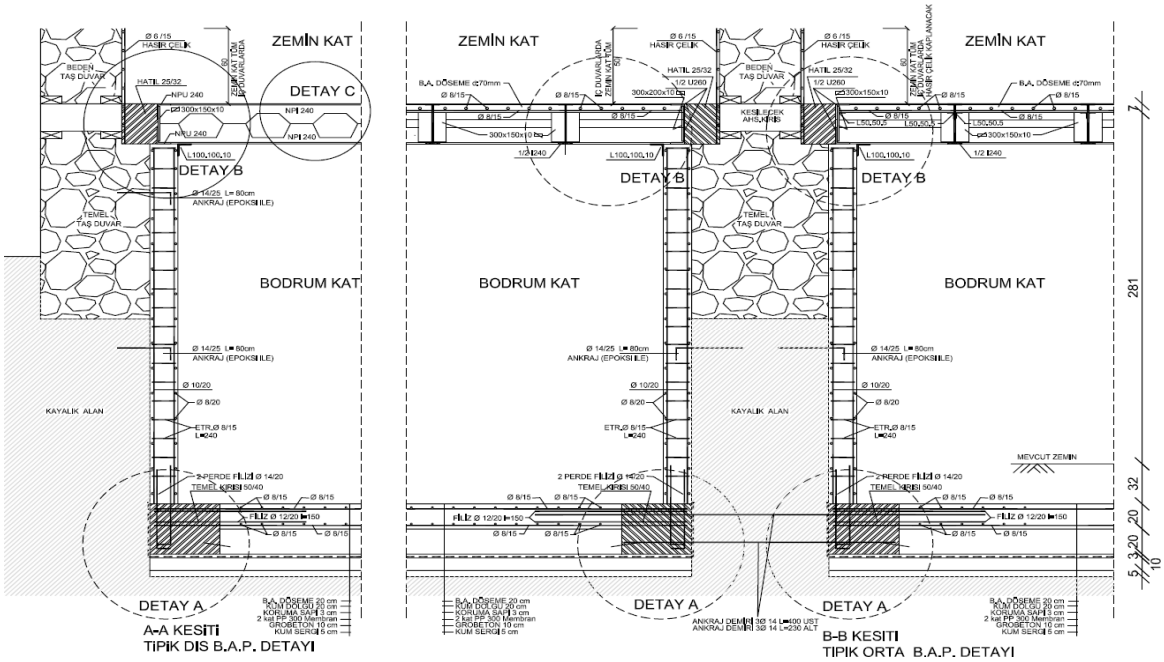

Figure 6: Detail of strengthing

Cutting force of wall fill that is strength with steel reinforcement mesh has been computed with equation 3. And this value has been compared with cutting force on the wall that taken result of analyzes.

$$V_{du\,\mathrm{var}} = A_{du\,\mathrm{var}} \times (\tau_{du\,\mathrm{var}} + f_{yd} \times \rho_{sh}) \le 0.22 \times A_{du\,\mathrm{var}} \times f_{du\,\mathrm{var}} \qquad (3)$$

In this equation, cutting force strength of reinforced wall is $V_{du\,\mathrm{var}}$ that Vertical section area is $A_{du\,\mathrm{var}}$, Compressive strength is $f_{du\,\mathrm{var}}$ and shear strength is $\tau_{du\,\mathrm{var}}$. If f_{yd} Design yield strength of reinforcement mesh is ρ_{sh}, this is rate of reinforcement of vertical body to gross cross section area on the wall.

Being example for computing; computing related with reinforcement mesh strength made for P111 walls has been applied fit with conditions of regulation and accounts shows below. Other reinforcing strength and cutting strength of walls show on Table 5. These values has compared with cutting force Table 4. Example of P111 wall;

$$V_{\max} = 181 ton,\ A_{du\,\mathrm{var}} = 36000\ cm^2,\ \tau_{wall} = 2.5\ kg/cm^2,\ f_{yd} = 5000\ kg/cm^2,\ L_{wall} = 5,78\ m$$

Φ6/15 Cedar anchor has been used according to standards for strength of walls. According to values that read on anchor cedar section table, reinforcement section area is 3,35 cm^2/m. If limit of flow to reinforcement from anchor cedar handles as 5000 kg/cm^2 ;

$$\rho_{sh} = \frac{section\ area\ of\ steel\ bars \times length\ of\ the\ wall}{area\ of\ the\ wall} \qquad \rho_{sh} = \frac{3,76 \times 5,78}{36000} = 6,04 \times 10^{-4}$$

$$V_{wall} = (36000 \times 2.5) + (36000 \times 5000 \times 6,04 \times 10^{-4}) = 212877\ kg > V_{max} = 181 ton$$

According to computing that made; values has been compared taken from result of analyze the resistance of cutting force of walls that has reinforced mesh and it was suggested that strength was necessary.

Table 5: sectional force resistance on strength walls

STIUATION AFTER STRENGTH OF ANTALYA GOVERNER'S OFFICE (Ton-m)									
Story	*Pier*	*V2EX*	*V2EY*	*V3EX*	*V3EY*	*V MAX*	*ALAN*	$L_{du\ var}$	$V_{du\ var}$
STORY3	P1	0.05	3.47	0.13	0.49	3.47	0.82	1.225	43.55
STORY2	P1	1.51	6.54	0.72	1.36	6.54	0.82	1.225	43.55
STORY1	P1	13.08	6.13	1.01	4.09	13.08	1.16	1.225	52.03
STORY3	P2	4.09	2.95	0.04	0.09	4.09	0.82	2.065	59.34
STORY2	P2	6.17	1.32	0.02	0.81	6.17	0.82	1.15	42.14
STORY1	P2	23.04	3.59	0.07	1.41	23.04	1.34	1.15	55.12
STORY3	P3	3.69	2.18	0.03	0.23	3.69	0.82	1.15	42.14
STORY2	P3	6.07	1.15	0.04	0.8	6.07	0.82	1.03	39.88

Because stair NPI 240 limon beams (made by German in 1860) was exposed corrosion and jagged and mostly broken in order to make bulk mosaic to stair, all of them was renewed based on main measure and equipments. Because barriers was broken and decomposed, stairs and profiles has been renewed fit with original. Anchor shutters (ground floor) have been ripped completely that put on windows carpentry. All windows have been renewed completely fit with original both reason of decomposing that occurred lack of care and climate holes.

Figure 7: Existent situation of stairs and windows

When floor covering that made later has ripped, it has painted with wood protector by cleaning because beams of conveyor cedar wood nervure has been perfect condition when floor conveyor that is in + 4.90 (first floor) elevation was ripped. It was determined that Into basement (+0.29), floor conveyor that made or found also was drawn up, north west room that had fired and beams of conveyor corridor cedar wood nervure was be harmed from fire largely, reinforcing disorderly, some part of them was decomposed. It accepted with statically that change of wood nervure beams that used for this floor with steel beams in same measure. (Fig. 8).

Figure 8: Removing of the damaged floor and making of the new floor with extra steel bars

Equipment has been put between mesh steels that used on covering; concreting has been done 10-12 cm on equipments. (Fig. 8).

Because all roof covering painted again and again, wood lost its feature, and some breaks occurred, it has been changed with same measure and form wood. Although roofs has seemed as painted in measured drawing and restoration projects, result of chemical analyzes, it has decided that protect all roof with using wood protector, because has determined wood gloss in first coat of roof paint. In entrance of structure, Limra doorjamb and other küfeki doorjambs, profiles and grouts on wall covering was ripped, grained paint under the grout was cleaned by raking. Broken and completely (all ground floor and balconies) removed doorjambs was repaired and renewed with method of decompose. (Fig. 9 and Fig. 10).

Figure 9: Picking up grouts and paints

Figure 10: Opening of Closed Windows

Conclusion

In this study, it tries to present restoration of historical school building in Antalya to strength. All point of structure has been handled with detail for the purpose of reflecting history of structure and transferring to future. In all detail, it has been stick to history, aesthetic, value, and identity of building. All professional disciplines has worked together, harms that made before has removed during restoration.

Because each structures have own details, it shows several characteristics both side of architectural and engineering. So that, every structure that work, each problems that faced on these structures show the way for coworkers who work similar case.

On the other hand, historical values, aesthetic, and identification of structure should be positioned in restoration and strength of historical structures. Intervention of structure must be minimum level and it must be done to stick original equipments.

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