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AN APPROACH FOR ESTIMATING TOTAL COST OF OCCUPATIONAL SAFETY FOR BUILDING CONSTRUCTIONS

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ABSTRACT: Construction accidents are major problem in Turkish Construction industry and especially fatally rates are very high. Current legislative system on occupational safety in Turkey enforces employers to implement safety measures as well as safety management systems. However level of consciousness in the industry is unsatisfactory and safety are perceived as extra cost and unnecessary expenditure. Moreover, especially in small residential building constructions which have a big share in the industry and unfortunately safety measures to mitigate or abate construction risks do not exist. The study focuses on small residential building construction sites and in the scope of this study, thirty building projects are examined. For each building project, project cost including labour and material costs, service and consultancy costs for mechanical, electrical systems as well as architectural and structural services, costs for supervision and finally general expenditures for construction site facilities were calculated. On the other hand, occupational safety costs for personal protective equipment, collective protective measures, consultancy and training were determined. Work breakdown structures were established and for each work item firstly occupational risks were evaluated and furthermore according to risk scores safety measures to be implemented were defined and related costs were calculated. The study gave results for total safety cost on average, in terms of percentage of total project cost (3.73% of total project cost), safety cost per man-hour (0.40 USD) and safety cost in terms of unit construction area (11.60 USD per square meter). Since safety management is a part of whole project management process, study gives suggestions and techniques to calculate safety costs and implement safety measures as a part of project management service for professionals. Authors believe that suggested approach may easily developed by the usage of more data to establish a model for estimation not only for building construction sites but also for all construction projects.

Keywords: Occupational Safety Management, Cost of Occupational Safety, Construction Risks.

1. INTRODUCTION

In recent years, not only in Turkey but all around the world, safety records in the construction industry are so inadequate that safety has become a matter of grave concern to government bodies and private enterprises. When safety assessments are desired to be made for construction sites, there is often inadequate data or imprecise information available [1]. Various safety management systems are introduced, pointing to effective monitoring of safety policies, procedures and practices within the companies. Safety practices encountered at construction sites are as variable as the sites themselves. Also, different companies tend to have different scales of safety management systems because of limitation of resources [2]. Current legislative system on occupational safety in Turkey enforces employers to implement safety measures as well as safety management systems. However level of consciousness in the industry is unsatisfactory and safety are perceived as extra cost and unnecessary expenditure. More specifically, in order to stay economically competitive and sustainable and to earn maximum profits, many contractors only execute basic safety measures and eliminate many important hazard prevention training programs during construction project implementation [3].

Any accident or incidens of ill-health will cause both direct and indirect costs and incur an insured and an uninsured cost. It is important that all of these costs are taken into account when the full cost of an accident is calculated. In a study undertaken by the Health and Safety Executive (of England), it was shown that indirect costs could be 36 times greater than direct costs of an accident. In other words, the direct costs of an accident or disease represent the tip of the iceberg when compared to the overall costs [4]. Health and Safety Executive (England) also gives Economic Analysis Unit (EAU) appraisal values give the unit costs to society for three kinds of workplace accidents and ill health: Fatalities, Non-fatal injury accidents; and average case of ill health. In all three categories the overall unit cost to society of an incident is divided into its component costs: human costs; cost of lost output; and resource costs [5]. Costs of the accidents have been a focus point for the safety experts and academicians in the field of occupational safety and health, plenty of studies which analysis cost of lost working days, insurance, delay in project duration exist in literature. However studies upon the cost of safety

measures as a part of project cost during a construction project are so rare. Tan [6] compared the cost of safety measures during a project and costs of accidents in Turkey. Panopoulos [7] seeks optimum safety cost by estimation of prevention cost, average accident cost and management failure with-no-accident cost and decides safety pays or not necessarily pays for a project. This research is an attempt to give an approach for safety cost estimation for residential building project contractors' bid estimate by utilization of risk assessment. Moreover, by implementation of approach suggested, contractors can easily prepare and implement their safety management plan on site.

2. SCOPE AND METHOD

2.1 Scope of the Project

In the scope of the project, drawings, technical specifications, bill of quantities of 30 concrete residential buildings in the region of Istanbul province are examined. Additionally, construction sites were visited and information gathered from the site engineers upon safety practices on site. Total areas of the projects vary between 400 and 2000 m^2. Since the cost of construction projects vary due to regional characteristics (different labour wages, different tax policies of the municipalities, variable transportation, material cost and additional cost due to site facilities), the study only focused on the projects in Istanbul province. Additionally, since surveillance of the projects in metropolitan cities performed better than the projects in the underdeveloped regions or projects very far from city centers, expenditures for consultancy, implementation of safety management systems or hiring safety professionals on site, unfortunately, differ from region to region in Turkey. Projects in the scope of the study are whether in the beginning of the construction phase or just after the design phase, that is, the proposed approach gathers data from project schedule (performed by contractor), drawings, bill of quantities (with unit prices) and cost estimation.

2.2. Determination of Risk Scores for Each Construction Activity

In this stage of the project, firstly work break down structures are established and for each item or sub-item, possible risks are listed. In Table 1. fundamental jobs to be performed in a concrete residential building and related occupational risks are listed. The main aim to perform hazard analysis and risk assessment is to determine the safety expenditures to prevent accidents by decreasing risk scores by the utilization of personel protective equipments, collective equipments and other equipments or techniques.

Table 1. Main Job Items for Building Construction

Jobs	Possible Hazards
Excavation	Cave-ins Fall into the excavation Struck by a falling object Building/Structure collapse (especially neighbor structures) Equipment accidents (roll over etc.) Struck by a moving vehicle Contact with underground electricity etc lines
R.C.C. works (Formwork cons., pouring concrete, re-bar bending , settlement etc.)	Fall from height Struck by flying/falling object Equipment accidents (concrete pump etc.) Manual handling hazards Hazards due to machine and tool usage Struck by electricity
Roof works	Fall from height Equipment accident (lifts, cranes etc.)
Masonry	Fall from height Equipment accident (lifts, hoists, cranes)
Elektrical and mechanical works	Contact with electricity Manual handling hazards
Plastering	Fall from height Struck by flying/falling object Equipment accident (hoists)
Painting	Fall from height Struck by flying/falling object Equipment accident (hoisting engine)
Grooting	Fall from height Struck by flying/falling object Equipment accident (pump, cranes etc.) Manual handling hazards Hazards due to machine and tool usage
Floor works (cons.of different floors, upper floors incl. water proofing, polishing**)**	Manual handling hazards Hazards due to machine and tool usage
Rebar workshop works, other metal works	Struck by flying/falling object Contact with electricity
Installation of doors and windows	Fall from height Manual handling hazards
Lift installation	Manual handling hazards Contact with electricity
Landscaping and related works	Manual handling hazards Struck by a moving vehicle
General site works	Fall onto ground Struck by a moving vehicle Equipment accident Contact with electricity

By the aid of the work breakdown structure for each work item, hazards are determined firstly. Secondly for each construction work item and sub-item risk assessment were performed by the utilization of accident severity and accident likelihood as input parameters. For accident likelihood and severity, conceptual framework and score of a former study performed by Gurcanli and Mungen [1] was used. However, 5x5 Risk Matrix is used to calculate the risk scores and according to the scores definition of risk for each sub-item. In Table 2. risk assessment form for excavation works for building construction is given as an example. According to the table, job, related hazards are depicted firstly, later on accident likelihood and severity values are given and multiplication of these inputs gives the risk score. Furthermore, the safety experts on site define the risks for each construction work item and determine the mitigation and abatement measure to prevent the possible accident. In the last two columns personal protective equipment (PPE) and collective protective equipment or technique is given. It is important to note that, many safety measures to be performed should be thought as a part of construction job rather than separate safety measure and/or expenditure. For example, for excavation works, shield - a structure able to withstand a cave-in and protect employees, shoring - a structure that supports the sides of an excavation and protects against cave-ins and sloping - a technique that employs a specific angle of incline on the sides of the excavation and other techniques are part of the job itself rather than separate safety measure. According to the regulations, specifications and standards it is necessary to follow the rules as a part of engineering principles. Therefore in this study all these types of safety measures were not calculated and not included in the "cost of safety". For the given example for excavation (and all other job items), personal protective equipments (in this case helmet and safety harnesses) and collective protective equipments (in this case fences, guardrails, safety signs) are depicted in the Table.

2.2. Calculation of Costs

Since the ultimate aim of the project is to give an approximate cost of safety (and list of safety measures, for budgeting safety equipments, techniques, training and consultancy services) to the contractors before bid and award phase or before the construction phase begins, for each building project, project cost including labour and material costs, service and consultancy costs for mechanical, electrical systems as well as architectural and structural services, costs for supervision and finally general expenditures for construction site facilities were calculated. On the other hand, occupational safety costs for personal protective equipment, collective protective measures, consultancy and training were determined.

Table 2. Risk Assessment and Cost Estimate Form for Excavation Works on Building Site

	Health and Safety Forms			
	RISK ASSESSMENT and COST ESTIMATE FORM FOR PROJECT #30			Date: Revision: Page:
JobSite/Project	Control Date	Report Date	Name of the Assessor	Sign of the Assessor

Job	Hazards	Accident Likelihood	Accident Severity	Risk Score	Definition of Risk Level	Safety Measures	PPE to be used	Collective Protective Equipment
EXCAVATION	Cave-in	5	5	25	Very High	General Safety Measures for excavation and underground operations that current regulations required	PPE Package for construction workers working at excavation jobsite (PPE-Ex)	Ladders
	Fall into the excavation	4	3	12	Average			Safety Signs, fences and guardrails
	Struck by a falling object	3	4	12	Average			
	Building/Structure collapse	1	5	5	Low			
	Equipment accidents	1	3	3	Low			
	Struck by a moving vehicle	1	3	3	Low			
	Damage of underground facilities. (electricity etc)	1	3	3	Low			
	Job Details (according to Ministry of Public Works Specification)	**Quantity (m3)**	**Total Man/Machine hour**	**Total Hours to complete**	**Duration of excavation activity***	**Minimum required worker**	**Unit Prices PPE per worker in USD (PPE-Ex Package)**	**Total cost for PPE-Ex (USD)**
	Excavation of loose soil with manpower	10,08	1,2	12,9	10	3	20.2	60.6
	Excavation of loose soil with excavator(hard or soft soil)	330,83	0,25	82,71		3		
	Excavation of compacted soil with excavator (hard or soft soil)	28,94	0,25	7,24		3		
	Gravelling and pouring sand	53,75	0,25	13,44		3		
	Compaction with aggregate	14,82	6	88,90		3		
	Soil compaction with manpower	125,25	1	125,25		3		

*From construction schedule prepared by contractor

Work breakdown structures were established and for every work item firstly occupational risks were evaluated and furthermore according to risk scores, safety measures to be implemented were defined and related costs were calculated.

In the first stage, a market research was performed to estimate the safety cost for each item and in this stage, not only costs of PPE's but also the costs of collective protective equipment such as fences, guardrails, stairs, roof stairs and so on are collected from the market. In the second stage, PPE packages are established for each workers working at different jobs through the project. For example, for workers working at excavation work, the package is titled as PPE-EXC (PPE for excavation worker, or PPE-Form (PPE for formwork workers) and so on. For each package consist of different combination of PPE's. Moreover, not just only for PPE's, but also collective protection costs are calculated. In Table 2. one can easily see the details of a certain construction job, quantities, man/machine hours, unit price for PPE-Package and total PPE cost for that job. Job details are explained according to Ministry of Public Work Unit Prices and Definitions Hand Book. By the utilization of the table it is very easy to estimate the cost of that specific job, related risks and PPE to reduce risk when performing that job. The man/machine hour values will also be used later to calculate safety cost per man-machine hour for the whole project. In Table 3. PPE packages for different occupations are shown.

Table 3. PPE Packages for Different Occupations

		Personal Protective Equipments	Helmet	Goggle	Dust mask respirator	Face Shield	Protective Clothing	Reflective work vests	Safety Harness	Safety-toe protective footwear	High Boots	Gloves	Cost (USD)
		Standards	CE EN 397	CE EN 166	CE EN149	CE EN 166		CE EN 471	CE EN 361	CE EN 345	CE EN 345	CE EN 388	
PPE_1	PPE-EXC	Excavation worker	●		●		●	●			●	●	14,24
PPE_2	PPE-FRM	Formwork Worker	●		●		●		●	●		●	44,37
PPE_3	PPE-IRW	Ironworker	●				●		●	●		●	43,98
PPE_4	PPE-CON	Concrete pouring	●			●	●		●	●		●	46,43
PPE_5	PPE- ROF	Roof worker, plumber	●		●		●		●	●		●	44,37
PPE_6	PPE-BRK	Bricklayer	●				●		●	●		●	43,98
PPE_7	PPE-PPT	Painter, Plasterer	●			●	●		●	●		●	46,43
PPE_8	PPE-ELC	Electrician	●				●			●		●	21,93
PPE_9	PPE-MEK	Mechanics, Plumber	●				●			●		●	21,93
PPE_{10}	PPE-FLR	Floor jobs worker	●	●			●			●			22,67
PPE_{11}	PPE-WEL	Welder	●	●	●		●			●		●	45,11
PPE_{12}	PPE-CAR	Carpenter	●	●	●		●			●		●	23,06
PPE_{13}	PPE-UNS	Unskilled	●				●			●		●	21,93
PPE_{14}	PPE-DWI	Door-Window ins.	●				●			●		●	21,93

In the third stage of the project, hazard analyses and risk assessment scores were used to determine collective protection measures and calculate associated costs for related construction activity. However when calculating the cost of safety measures, overall project was examined to determine mitigation and abatement techniques, equipment and tools by the aid of by the aid of architectural and technical drawings, bill of quantities, specifications and construction schedule. It is not preferred to divide the cost of collective protective equipments for each job (item or sub-item) because of two reasons; firstly it is very difficult to divide collective safety measures and secondly many construction activities or many hazards which are resulted from the nature of those jobs can be eliminated or associated risks can be mitigated together. For example, floor openings have risks of fall from height and falling objects, and installation of guardrails is not only necessary while floor works are being done, but also necessary and required when electrical and mechanical installations while workers working on the floors. It is also impossible to divide the installation of fencingç One way to clearly delineate the boundaries of a construction site is by erecting a fence around the perimeter of the area under construction. By ensuring that work is carried out within well-defined borders, the public can be kept safe from potentially life threatening accidents. Furthermore, construction site workers will have a secure area in which to conduct their work. Installation of fences can prevent or reduce many risks (due to excavation, heavy equipment works and so on) and you have to install at the beginning of the project initiation. Therefore, especially by the aid of the architectural and technical drawings and the schedule of the project, safety items such as safety signs, fences, guardrails, cover sheets, safety nets, first aid, fire protection tools and so on were determined andn associated costs were calculated for 30 building projects. In Table 4, Collective Protection Measures and related techniques are given. For the calculation of the total cost of collective protection measures unit prices are collected from the market research.

Each item should be calculated by the aid of architectural and technical drawings and total quantity should be found. For instance, in some cases it is necessary to prevent people to enter the working radius of a crane with fences or in some cases with safety tapes or in some cases floor openings can easily covered with wooden cover, timbers etc, but sometimes it is required to install guardrails. All these decision making process need

hazard analysis and risk assessment scores performed by the safety expert by the aid of Table 2 or similar forms. Therefore it is very important to collaborate with safety experts before the bid-award phase to estimate safety expenditures for the contractors. The level of risks for each construction activity determines the level of safety expenditure to eliminate that hazard.

Table 4. Collective Protection Techniques, Equipments and Tools

Required Measure	Techniques, Equipments or Tools Required	Unit/ Unit Price	Total Qty	T. Cost
C_1 Protect workers and public from the hazards of site and excavation	Fencing around the site Standard warning signs Safety tapes			
C_2 Protect workers from falls into floor openings, hoist areas and slab edges	Guardrails Covering with Timbers Safety Nets Safety Tapes			
C_3 Prevent workers or public to enter the working radius of cranes, hoists etc.	Fences Safety Tapes			
C_4 Prevent workers or public from falling objects	Fences Safety Nets Guardrails.			
C_5 Prevention of tile breaks, fall from edge, fall from skylights	Slide guards on the roof Timbers on skylights Roof ladders			
C_6 First Aid and Fire Protection	First Aid Tool Boxes Fire Protection Tools			

After these steps, consultancy and training costs were calculated. Unfortunately, according to the Turkish legislation, job sites that employ less than 50 employers are not required to hire a safety experts/professionals and majority of our building projects could be conducted less than 50 workers. However, in the study, whether the regulations required or not, it is assumed that a safety consultancy and training service of an expert once in two weeks throughout the project for a fixed 12 months project duration and it is calculated as 3675 USD data gathered from the market research (from consultant firms). This price is the minimum price and includes auditing and training.

Finally safety cost of a building project can be expressed as follows:

$$\text{Safety Cost} = PPE_{Cost} + CPE_{Cost} + ST_{Cost} \quad (1)$$

$$PPE_{Cost} = \sum_{i=1}^{n} (PPE_i \cdot N)$$ (See Table 3 for PPE_i, N=#of workers at that activity, n=14) (2)

$$CPE_{Cost} = \sum_{i=1}^{n} C_i$$ (See Table 4, n=6) (3)

ST_{Cost} = 12x2x1xSTD_{daily} (STD_{daily} =153.13USD from the market research) (4)

3. RESULTS AND DISCUSSION

Of course the costs of a construction project to the owner include both the initial capital cost and the subsequent operation and maintenance costs. However in this study, the point of view is from the contractors angle and our project procurement methods are traditional, that is, design-bid-build. Therefore the total cost for a construction project includes the expenses below:

-Construction, including materials, equipment and labor

-Project Service expenses such as architectural and engineering (mechanical, electrical, civil engineering) design review and control services, project control and supervision expenses

-Contractor's site office and general office overhead

-Health and Safety Expenses

As mentioned before calculation of construction cost was performed with the approach of "Unit costs for bill of quantities". A unit cost is assigned to each of the facility components or tasks as represented by the bill of quantities. The total cost is the summation of the products of the quantities multiplied by the corresponding unit costs. The unit cost method is straightforward in principle but quite laborious in application. The initial step is to break down or disaggregate a process into a number of tasks. Collectively, these tasks must be completed for the construction of a facility. Once these tasks are defined and quantities representing these tasks are assessed, a unit cost is assigned to each and then the total cost is determined by summing the costs incurred in each task. In this project the level of detail was determined according to the Unit Cost Analysis Handbook issued by Ministry of Public Works and standard construction activities for building constructions presented by Kuruoglu [8]. It is assumed that the contractor's site office and general office overhead is approximately %4 of the construction cost (it is a common approach in Turkey, but one can easily develop a new approach for these expenses).

Project services includes following expert services required by the related Chamber of Engineers such as:

-Reinforced concrete-structural project services (its cost is determined by the regulation of Chamber of Civil Engineers)

-Mechanical installation project services (its cost is determined by the regulation of Chamber of Mechanical Engineers)

-Architectural project services (its cost is determined by the regulation of Chamber of Architects)

-Electrical installation project services (its cost is determined by the regulation of Chamber of Electrical Engineers)

-Construction supervision and control expenses (determined by the regulation on Construction Supervision and Control Practices Rules and Principles Regulation)

All these service expenses were calculated according to

the formulae for different building classes in the regulations.

3.73% in average. 0.4 USD per man-hour is required to construct the project safely and 11.6 USD average value

Table 5. Summary of Total Costs for 30 Building Projects

		Construction Cost (in USD)			Safety Cost (in USD)						
	Total Project Area (m^2)	**Construction, including materials, equipment and labor**	**Project services**	**Contractor's site office and general office overhead**	**PPE_{Cost}**	**CPE_{Cost}**	**ST_{Cost}**	**Total man/ machine hour to be spent for the project**	**% of Safety Cost to Total Cost**	**Safety cost for per man/machine hour**	**Safety cost per unit construction area**
P1	1055,20	259624,6	35206,9	11793,3	2761,6	2327,6	3675,0	29.126,27	2,78	0,30	8,31
P2	357,40	97265,5	14583,7	4474,0	2270,0	1359,2	3675,0	11.771,48	5,91	0,62	20,44
P3	1331,60	324677,5	43060,4	14709,5	3057,9	3111,6	3675,0	36.001,28	2,51	0,27	7,39
P4	911,66	226276,9	31439,1	10308,6	2531,6	2557,8	3675,0	25.558,30	3,17	0,34	9,61
P5	1075,59	264143,3	35759,4	11996,1	2761,6	2994,0	3675,0	29.632,64	2,93	0,32	8,77
P6	539,83	139587,0	20798,8	6415,4	2334,5	2571,0	3675,0	16.308,26	4,89	0,53	15,90
P7	659,90	168189,1	24525,4	7708,6	2334,5	2866,9	3675,0	19.295,74	4,24	0,46	13,45
P8	748,00	188266,1	27078,1	8613,8	2400,8	3510,1	3675,0	21.486,68	4,10	0,45	12,82
P9	1251,30	305053,5	40837,2	13835,6	2927,2	3040,8	3675,0	34.003,50	2,61	0,28	7,71
P10	1227,77	299877,7	40145,3	13600,9	2927,2	3525,8	3675,0	33.417,86	2,78	0,30	8,25
P11	1517,66	368302,7	48089,2	16655,7	3351,0	3607,8	3675,0	40.629,89	2,49	0,26	7,01
P12	405,12	109717,1	16251,3	5038,7	2270,0	1766,8	3675,0	12.960,52	5,77	0,60	19,03
P13	1124,56	276856,4	37306,5	12566,5	2761,6	3047,2	3675,0	30.852,34	2,93	0,31	8,44
P14	473,50	124970,3	18583,2	5742,1	2270,0	1385,6	3675,0	14.659,54	4,86	0,50	15,48
P15	441,34	117682,1	17422,1	5404,2	2270,0	1648,8	3675,0	13.860,34	5,32	0,55	17,21
P16	603,55	155621,4	22835,9	7138,3	2334,5	2860,2	3675,0	17.895,92	4,73	0,50	14,69
P17	777,19	196066,2	27902,2	8958,7	2400,8	2482,2	3675,0	22.214,99	3,68	0,39	11,01
P18	544,42	140928,9	20941,8	6474,8	2334,5	1322,1	3675,0	16.423,89	4,33	0,45	13,47
P19	628,47	161139,4	23586,9	7389,1	2334,5	1604,3	3675,0	18.514,45	3,96	0,41	12,12
P20	555,24	143551,8	21288,1	6593,6	2334,5	1153,9	3675,0	16.692,41	4,16	0,43	12,90
P18	544,42	140928,9	20941,8	6474,8	2334,5	1322,1	3675,0	16.423,89	4,33	0,45	13,47
P19	628,47	161139,4	23586,9	7389,1	2334,5	1604,3	3675,0	18.514,45	3,96	0,41	12,12
P20	555,24	143551,8	21288,1	6593,6	2334,5	1153,9	3675,0	16.692,41	4,16	0,43	12,90
P21	775,93	195710,6	27857,6	8942,7	2400,8	1277,8	3675,0	22.183,07	3,18	0,33	9,48
P22	924,97	229170,2	31789,0	10438,4	2564,5	1886,3	3675,0	25.885,47	3,02	0,31	8,79
P23	1092,50	268196,0	36315,3	12180,5	2761,6	1766,5	3675,0	30.053,60	2,62	0,27	7,51
P24	644,44	164708,0	24068,1	7551,0	2334,5	1605,7	3675,0	18.916,26	3,88	0,40	11,82
P25	748,20	188317,9	27085,2	8616,1	2400,8	2296,8	3675,0	21.491,59	3,74	0,39	11,19
P26	521,40	135524,5	20160,6	6227,4	2334,5	1404,5	3675,0	16.346,78	4,55	0,45	14,22
P27	882,77	219495,4	31145,5	10025,6	2531,6	1694,3	3675,0	24.838,89	3,06	0,32	8,95
P28	879,39	218755,0	30585,9	9973,6	2531,6	3000,3	3675,0	24.753,95	3,56	0,37	10,47
P29	784,20	197587,0	28150,3	9029,5	2400,8	2031,6	3675,0	22.388,02	3,47	0,36	10,34
P30	1188,82	289705,5	39083,5	13151,6	2894,2	2531,2	3675,0	32.301,03	2,69	0,28	7,66
								Average	3,73	0,40	11,60

As seen in Table 5, share of the safety expenses in the total cost of a building project (construction plus safety) should be spent for a unit construction area. It should be noted here that as the total area of the project increases,

the share of the safety expenses decreases. This is because of the assumed fixed expenses for the safety training and consultancy, in other words this figure is same for all projects. Moreover, some expenses such as fencing around the site or excavation area do not depend on the total area, but the area of the construction site, for instance the fencing cost for a 10 storey building and 3 storey building erected on a same land is same! On the other hand, the average figures give us a range between 2 and 5 percent and this estimation is very precious for the contractors who want to estimate the bidding cost. Cost estimating is one of the most important steps in project management. A cost estimate establishes the base line of the project cost at different stages of development of the project or preparing for the bidding phase. For the contractor, a bid estimate submitted to the owner either for competitive bidding or negotiation consists of direct construction cost including field supervision, plus a markup to cover general overhead and profits. The direct cost of construction for bid estimates is usually derived from a combination of subcontractor quotations, quantity takeoffs and construction procedures and many times safety cost is not taken into consideration. A cost estimate at a given stage of project development represents a prediction provided by the cost engineer or estimator on the basis of available data and to gather more data provides better estimation. Authors argue that the collected data may be analysized with different regression methods to model the relationship between type of construction, total area of construction and percentage of safety expenditures. In this study a basic linear regression applied to the data shown in Table 5. and relationship between total area of construction and share of safety cost in total cost was analyzed. Regression analysis gives relationship shown below:

$$y = -0.0028x + 5.9461 \qquad R^2 = 0.8384 \qquad (5)$$

y represents here the percentage of safety cost in total project cost and x is the total area of the construction. The linear relationship of course just gives us a point of view or starting point for further analyses. However at this stage, the formula gives very practical way to estimate share of safety cost in total project cost for residential building projects. Additionally, contractors can prepare safety plans and organization and allocate required budget to safety measures not only for cost control or project management but also save human life and protect their workers.

4. CONCLUSION

The contractor's bid estimates often reflect the desire of the contractor to secure the job as well as the estimating tools at its disposal. Some contractors have well established cost estimating procedures while others do not. Since only the lowest bidder will be the winner of the contract in most bidding contests, any effort devoted to cost estimating is a loss to the contractor who is not a successful bidder. Consequently, the contractor may put in the least amount of possible effort for making a cost estimate if it believes that its chance of success is not high. If a general contractor intends to use subcontractors in the construction of a facility, it may solicit price quotations for various tasks to be subcontracted to specialty subcontractors. Thus, the general subcontractor will shift the burden of cost estimating to subcontractors. However for safety expenditures general contractors are not so relax. Especially for collective prevention of workers they have to spend money in every parts of the project. Furthermore, legally, they are responsible for all risks and accidents caused by them. Therefore supervision and control of the subcontractors is very important to mitigation and abatement of the occupational risks. If all or part of the construction is to be undertaken by the general contractor, a bid estimate may be prepared on the basis of the quantity takeoffs from the plans provided by the owner or on the basis of the construction procedures devised by the contractor for implementing the project and can manage the overall project, can easily prepare his/her safety plan, implement item by item hazard analysis and risk assessment and distribute tasks to subcontractors. In fact, construction of a more reliable model needs more data for building projects. However it is believed that the results may motive researchers, academicians and project manager professionals for further research and analyses. Briefly, authors argue that the proposed approach not only provides cost estimation for safety but also facilitates to prepare safety management plan required by law, regulations and standards such as OHSAS 18001.

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