



## ECONOMICAL LOSS DUE TO NON-COMPLIANCE WITH REQUIREMENTS FOR PERSONNEL SAFETY AND HEALTH IN LITHUANIAN CONSTRUCTION SECTOR

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**Abstract.** Research on *Economic Losses (consequences) due to Failure to Ensure Occupational Safety and Health Requirements in the Construction Sector* was conducted by the order of the Ministry of Social Security and Labour (contract No. 2594-AP). The conducted scientific analysis shows the state of occupational safety and health at work in the construction sector, estimates economic consequences for accidents at work, indicates the economic benefits of investment for occupational safety and health and presents the results of research, findings and recommendations. This would allow to reduce occupational diseases and the number of accidents at work and herewith to avoid economic consequences for state and construction enterprises.

**Keywords:** safety and health at work, accidents at work, economical losses, construction sector.

### 1. Introduction

Construction works are specific and present one of the most dangerous business fields. The reasons why occupational accidents in the construction field occur have a number of various causes (Šukys 2004; Liaudanskienė *et al.* 2010; Hola 2007). Significant reasons directly influencing accidents at work in the construction sector include a shortage of knowledge and training, a lack of supervision, awareness about the safe implementation of assigned work, i.e. negligence, apathy and total carelessness (Findley *et al.* 2004; Duijm *et al.* 2008). This is called unsafe behaviour and is suppose to be one of the fundamental factors influencing accidents at work, which shows a poor safety culture in a company (Macedo and Silva 2005; Behm 2005; Carter and Smith 2006; Hoła 2006a, 2006b, 2010).

The analysis of accidents considering harm factors has revealed that the majority of occurring factors are a fall from height, collision with a mean of transport, tumble and stumble, falling objects (Halsam *et al.* 2005; Déjus 2007; Hinze *et al.* 2006; Hinze and Giang 2008; Rozenfeld *et al.* 2010). These factors mostly cause serious and fatal accidents at work. The highest injury probability is for an employee who is working at a new place first year, and injuries are suffered by younger employees (Hoła 2009; Giretti *et al.* 2009).

A safe workplace is a way of successful business. Now, when the world of work is changing, health problems related to work are also changing. Occupational health and safety are becoming the priorities of all research fields all over the world (Teo and Ling 2006;

Nielsen 2007; López *et al.* 2008; McDonald *et al.* 2009; Liaudanskienė *et al.* 2009). Many construction companies are slowly building safe working items; however, due to injuries, large financial losses are suffered, pecuniary penalties are paid and potential working force is being lost. Today, the prevention of accidents at work in construction companies is a very important issue in Lithuania (Déjus and Viteikienė 2003; Déjus 2009; Stankiuvienė *et al.* 2006). A safe and healthy work environment is the most important condition for leading working life. The employee's efficiency along with general and occupational morbidity depends on the quality of working conditions. Due to employees' morbidity, disability and occupational diseases, significant economic losses are suffered by an employer. In construction business, the risk factor is very high. The risk assessment problem is analyzed by many authors (Vaidogas and Juocevičius 2008; Zavadskas *et al.* 2010; Zavadskas and Vaidogas 2008; Perera *et al.* 2009; Hallowell and Gambatese 2009). It is usually impossible to implement all accident preventive measures to eliminate all injury factors.

In 2003, attention was paid to safe working conditions at construction sites. This year, the campaign called "Building in safety" launched in all EU countries. During this campaign, special attention was paid to the deaths and injuries caused by a fall from height, falling objects etc. (Čyras *et al.* 2004; Šukys *et al.* 2005; Stankiuvienė *et al.* 2007; Vaidogas and Juocevičius 2009; Kleiner *et al.* 2008; Reinold *et al.* 2008).

Work is a very important and relevant factor. The cost of occupational health and safety influences the employees' health and well-being, thus making better work-

ing conditions and increasing motivation. All these have an effect on work quality, a decrease in accidents and the number of occupational diseases. What is more, the consumption of material and time for task accomplishment is decreasing, the prestige of company as well as the competitiveness is increasing. The identification of accidents and their economical consequences are very important to economy development. This kind of analyses in the construction field has been performed for the first time.

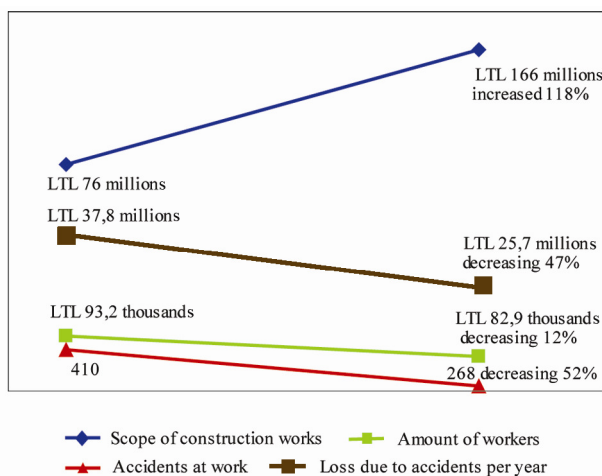
**Research objective** is to analyse personnel safety and health conditions in the construction sector for the period 2002–2009; to determine the economical loss (consequences) of building companies incurred due to the unsecured requirements for personnel safety and health as well as to prepare recommendations on lowering the incurred loss.

**Research methods.** In order to achieve the objective, selection, surveying and statistical-analytical as well as mathematical modelling methods were implemented.

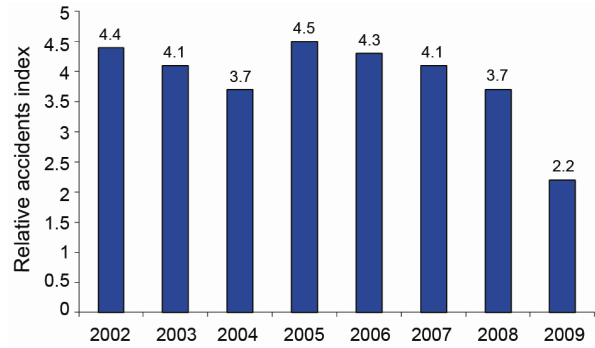
### 2. Analysis of Personnel Safety and Health in the Construction Sector for the Period 2002–2009

According to the data acquired by the Department of Statistics in 2008, there were 5476 active entities where the number of active individual entities made 1198. During 2009, building companies implemented works on their own resources for LTL 166.3 million, i.e. 2.1 times more than during 2002. The amounts of construction works, comparing with those in 2002, increased by 118%, the amount of personnel – decreasing by 12%, loss due to accidents – by 47% and the number of accidents – by 52% (Fig. 1).

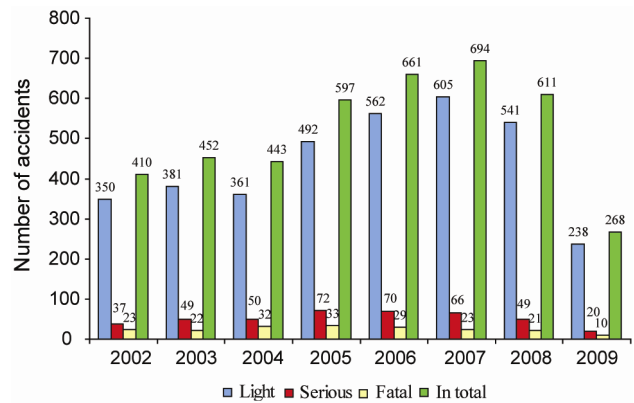
Comparing the number of accidents related to the construction sphere (a considering number of accidents per 100,000 employees), it can be mentioned that the number of accidents in 2009 compared to 2005 decreased by half. Data about the level of work accidents related to construction (accidents per 100,000 workers) for the period 2002 to 2009 is shown in Fig. 2.



**Fig. 1.** The dynamics of the amounts of construction works (LTL millions), personnel (thousands), loss due to the number of accidents per year (LTL million) and the number of accidents for the period 2002–2009



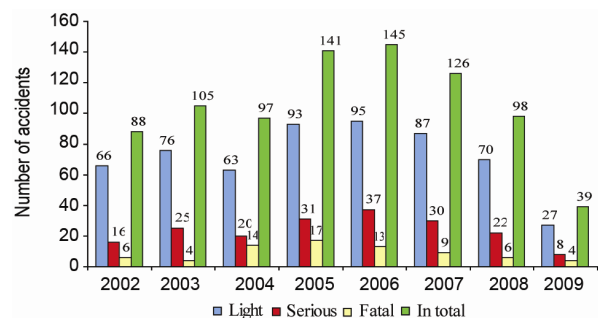
**Fig. 2.** The level of work accidents related to construction (per 100,000 workers) from 2002 to 2009



**Fig. 3.** The dynamics of the number of accidents at work (N-1 form acts) in building companies for the period 2002–2009

Considering particularity, construction is one of the most dangerous branches of economy. For the period 2002–2009, in the construction sector, 4136 workers were injured, 413 of them – seriously and 193 were killed. The overall amount of accidents in building companies decreased (Fig. 3) (State Labour Inspectorate 2008).

After the analysis of accidents in the construction sector, according to trauma factors, it was estimated that the largest amount of traumas – 24% was caused due to a fall from height (2005 year). The danger of falling and tumbling is always faced on construction sites when work is carried out on roofs, in buildings, on constructions, decks, platforms, stages, passages etc. The highest amount of accidents due to a fall from height reached 145 in 2006. Data on the accidents due to a fall from height in the construction sector is provided in Fig. 4.



**Fig. 4.** A number of accidents at work in the construction sector that occurred due to a fall from height in the period 2002–2009

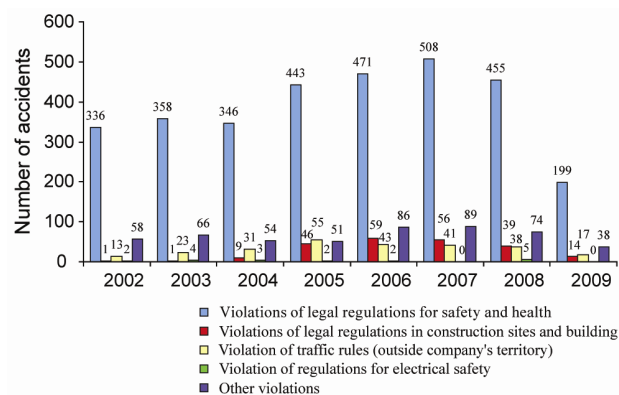
After the analysis of accidents considering reasons, it was noticed that the major part of the accidents occurs due to the violation of safety and health acts at work (508 cases in 2007). In 2007, 89 accidents occurred also due to other violations: criminal acts of violence, an unpredicted natural phenomenon, the violation of orders determining working and rest time etc. Data on accidents at work according to their reasons for the period 2002–2009 is provided in Fig. 5.

Approximately 23% of seriously injured and approximately 37% killed workers in construction were drunk during the accident. Considering all drunken workers killed at work, almost every second worker worked for building companies. This is one of the biggest problems in the construction sector (Fig. 6).

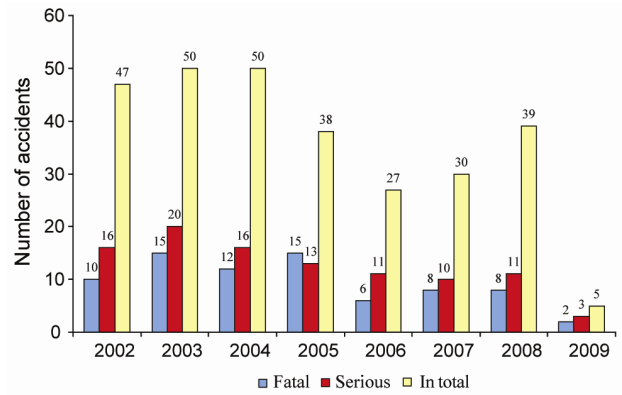
Approximately 55% of accidents occur in building companies with the number of personnel from 50 to 249. This happens in medium-sized companies due to the following reasons:

- the scope of construction objects is relatively small, their number is large; nature, technology and working conditions often vary; risk assessment is not carried out;
- site managers take part in several construction sites at the same time; therefore the supervision of personnel safety and health is poor. Approximately 50% of injured workers were drunk in these companies;
- the managers of subdivisions do not explain the personnel about the dangers on the construction site, their consequences and means of precaution, do not instruct the personnel before the commencement of work on a new construction site, and therefore workers take decisions themselves. Collective protection measures are not used on all sites.

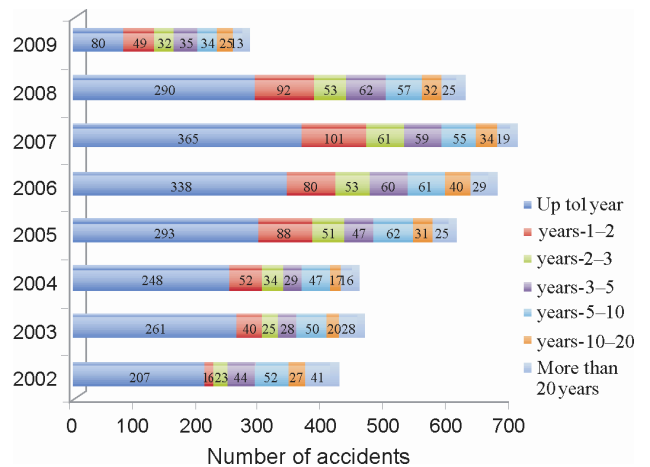
Mostly, accidents are experienced by the workers during the first year at work. They are not informed about dangers on the construction site, their consequences and protection measures and do not have the required qualification (Fig. 7).



**Fig. 5.** The number of accidents at work, for which the acts of N-1 form were prepared and specified according to their reasons



**Fig. 6.** The distribution of the number of accidents at work in relation to inebriation



**Fig. 7.** The distribution of accidents at work according to the period of work experience in a company

Workers at the age from 35 to 54 experience injuries most frequently. An increase in the injuries to the workers of this age is caused by the following reasons:

- lately, the extent of construction works has decreased considerably; at the same time, demand for working force and salaries have decreased;
- workers who has worked in the constructions sector for more than 10 years do not pay proper attention to risk factors because they feel experienced and knowing everything about construction works;
- every day, before the commencement of work, the managers of subdivisions do not inform workers about risk factors and carry out only formal instruction.

### 3. Economical Consequences of Accidents at Work

#### 3.1. Nationwide Loss Due to Accidents in Building Companies

The following costs were estimated during the evaluation of economical nationwide consequences of accidents at work:

- Social insurance benefits per year due to accidents at work;

- Non-produced GDP part during non-working days due to the accidents;
- Loss due to partial disablement:
  - due to accidents at work per year;
  - due to accidents at work within the period remaining till retirement;
- Cost-related to social insurance contributions due to the accidents that occurred at work.

The non-produced GDP part in the country during non-working days due to accidents ( $n_a$ ) is calculated by the following equations (Čyras and Šukys 2003; Stankiuviėnė 2008; Šukys *et al.* 2008):

$$n_a = G_d \cdot S_{na}, \quad (1)$$

where  $G_d = P / S / D$  – GDP part produced by one worker during 1 working day;  $P$  – GDP produced in the country during a year (Table 1);  $S$  – the number of working days in a year (Table 1);  $D$  – the number of workers (Table 1);  $S_{na}$  – the number of non-working days per year due to accidents at work:

$$S_{na} = N_{na} \cdot V_{na}, \quad (2)$$

where  $N_{na}$  – the number of accidents in the construction sector (Table 1);  $V_{na}$  – the number of days lost due to one accident at work (Table 1).

Loss incurred after partial disablement due to serious accidents ( $P_{1na}$ ) per year is calculated by using the following formula:

$$P_{1na} = k \cdot N_{na} \cdot G_m, \quad (3)$$

where  $k$  – the ratio estimating the average reduction of efficiency in percentages due to the accidents per year. (Calculations show that this ratio is equal to 0.2, i.e. an average 20% of efficiency is lost);  $N_{na}$  – the number of workers that experienced serious accidents (Table 1);  $G_m$  – the amount of GDP part generated by one worker per year. It is calculated as follows:

$$G_m = P / D, \quad (4)$$

Loss incurred due to not worked years when a worker would be able to work till his/her retirement if not disablement due to the accident ( $P_{2na}$ ):

$$P_{2na} = k \cdot n \cdot N_s \cdot G_{vm}, \quad (5)$$

where  $n$  – the average number of years when a worker could work till his/her retirement if not disablement due to the accident. Statistically, the average number of years left till the retirement of a person that experienced an accident at work is 22.  $G_{vm}$  – GDP created by one person within the last year;  $N_s$  – the number of serious accidents in the construction sector.

Loss due to fatal accidents per year  $P_m$  is calculated as follows:

$$P_m = K_f \cdot N_m, \quad (6)$$

where  $K_f$  – the conditional cost of one fatal accident. According to the estimations of English economist Andrew Oswald, one death in a country of the European Union “costs” EUR 21000 per month. After Lithuania became a member of the EU, this estimation can be applied conditionally. Within one year, this estimation can reach LTL 869.4 thousands.  $N_m$  – the number of fatal accidents at work per year in the construction sector (Table 1).

When estimating the loss, the percentage of work-related accidents that occurred in the construction sector was used. Calculation results on the occurred accidents at work nationwide are provided in Table 2.

Calculations implemented according to formula (6) are not fully accurate. Only a rough estimate of loss can be calculated by considering the current data. The obtained results show the indicative values used to create a clear general view on loss due to not worked years when a worker could work till his/her retirement if not disablement due to the accident.

Nationwide loss due to work-related accidents that occurred in building companies per year decreased from LTL 37.8 millions in 2002 to LTL 25.7 millions in 2009. For the period 2002–2009, the amount of loss reached LTL 398.6 millions.

Starting from 2006, social insurance contributions have been paid for accidents at work. Employers are required to pay differentiated social insurance contributions for accidents at work. The amount of these contributions varies depending on the number of persons suffering

**Table 1.** Data about general situation in the country (Department of Statistics 2002–2009, State Labour Inspectorate 2002–2009)

Year	2002	2003	2004	2005	2006	2007	2008	2009
GDP, LTL million ( $P$ )*	51971	56804	62587	71380	81905	98139	111190	92353
Average number of working days ( $S$ )	253	254	255	252	247	249	253	254
Number of workers in the construction sector, thousand persons ( $D$ )	93.2	107.1	116.2	132.5	148.7	170.9	166.5	122.6
Number of accidents in the construction sector ( $N_{na}$ )	410	452	443	597	661	694	611	268
Number of serious accidents in the construction sector ( $N_s$ )	37	49	50	72	70	66	49	20
Number of fatal accidents in the construction sector ( $N_m$ )	23	22	32	33	29	23	29	10
Number of lost days due to one accident at work ( $V_{na}$ )	28.05	21.83	28.39	36.99	34.86	34.66	35.6	36.4

\*1 € = 3.4528 LTL

**Table 2.** Nationwide loss due to accidents at work in building companies for the period 2002–2009 (LTL thousands)

Year	Loss per year					In total
	Unproduced part of the GDP per year due to accidents at work, $P_{na}$	Benefits of the social insurance fund per year	Loss due to fatal accidents per year	Loss due to serious accidents per year, $P_{Ina}$	Loss due to the accidents within the period remaining till retirement $P_{2na}$	
2002	2097	3281	19996	341	12088	37803
2003	1911	3263	19127	482	16009	40792
2004	2589	6243	27821	525	16335	53513
2005	5112	6971	28690	840	23524	65137
2006	6017	9557	25213	903	22870	64560
2007	7173	8945	19996	980	21563	58657
2008	7187	9535	18257	819	16662	52460
2009	2968	6938	8694	309	6801	25710
In total:	35054	54733	167794	5199	135852	398632

**Table 3.** Loss of building companies due to accidents at work per year, LTL thousands

Loss	2002	2003	2004	2005	2006	2007	Total
Loss on the transportation of a casualty to the medical institution or home (except the emergency medical service)	205.0	187.6	166.1	208.9	264.4	416.4	1448.4
Loss related to the reconstruction of safe working conditions on the accident site	1189.0	915.3	631.3	716.4	991.5	1388.0	5831.5
Loss due to broken equipment, tools, etc.	205.0	226.0	310.1	358.2	396.6	832.8	2328.7
Cost of investigation into accidents	533.0	1025.0	1550.0	1492.5	1718.6	1943.2	8262.3
In total:	2132	2353.9	2657.5	2776	3371.1	4580.4	17870.9
Company's lost profit (uncompleted works, downtime)	2093.1	1904.3	2590.7	5101.4	6013.8	7168.3	24871.6
In total:	4225.1	4258.2	5248.2	7877.4	9384.9	11748.7	42742.5

from fatal or serious accidents. The amount of costs calculated by building companies and related to social insurance contributions for the occurred accidents at work was LTL 12.2 millions in 2006 and LTL 15.4 millions in 2007.

### 3.2. Loss of Building Companies Due to Accidents

While estimating the loss of building companies due to accidents at work, the data obtained conducting a survey of building companies, was used. The total amount of loss due to accidents at work increased from LTL 4.2 millions in 2002 to LTL 11.7 millions in 2007; in total, for the period 2002–2007, the amount of loss made LTL 42.7 millions.

The major part of loss is related to the reconstruction of safe working conditions at an accident site (LTL 1.4 million) as well as to the cost for investigations into the accidents (LTL 1.94 million) (in 2007). Data on the loss of the overall building companies due to the accidents for the period 2002–2007 is provided in Table 3.

### 3.3. Calculation of Loss Adopting the Method of Direct and Indirect Costs

Loss estimation methodologies applied in foreign countries (Jurvansuu et al. 2000; TCO Development 2000) and loss due to the accidents is divided into direct costs

and indirect ones. Direct costs due to the accidents are as follows:

- payment costs for temporal disability;
- social benefit after professional disablement or death;
- benefits to the injured or persons having a right to receive such benefit in case of death of the injured;
- medical, social and professional rehabilitation expenses and other fixed costs.

The benefits of the social insurance fund are classified as direct costs (Table 2).

Indirect costs are as follows:

- costs related to investigation into the accident;
- unfinished production on an accident day;
- damage to equipment and tools;
- loss of raw materials, other materials and production, etc.

Various methodologies are applied for estimating indirect costs in foreign countries. American scientists suggested estimating the ratio between direct and indirect costs as 1:5 (this suggestion is accepted as reasonably accurate). In Finland, this ratio ranges from 1:4 to 1:6.

Results on the loss incurred due to accidents at work obtained by estimating direct and indirect costs by applying 1:5 ratio between direct and indirect costs are provided in Table 4.

**Table 4.** Calculation of loss incurred due to accidents at work according to direct and indirect costs, LTL thousands

Year	2002	2003	2004	2005	2006	2007	2008	2009
Direct costs	3281	3263	6243	6971	9557	8945	9535	6938
Indirect costs	16405	16315	31215	34855	47785	44725	47675	34690
Loss according to the direct and indirect costs	19686	19578	37458	41826	57342	53670	57210	41628

The loss incurred due to accidents at work, after estimation according to direct and indirect cost, reaches LTL 328.4 millions for the period 2002–2009. The difference between the loss incurred due to accidents at work, calculation methodology when direct and indirect costs are used and the ratio between the direct and indirect cost of 1:5 are applied, and the suggested loss calculation methodology (without the estimation of loss due to not worked years when a worker could work till his/her retirement if not disablement due to the accident) is equal to approximately 17%.

### 3.4. Economical Benefit of Investment in Personnel Safety and Health

Investment in personnel safety and health is considered as company's operating costs. Investment in personnel safety and health contributes to the personnel health and welfare, improves working conditions and increases motivation, which improves work quality. As a result, the number of accidents and occupational diseases, expenditure for materials and the period of work implementation decrease. The company's status as well as competitive ability increase, which is very important in the context of crisis.

After the estimation of these factors, company's costs can be lowered and financial indexes could be improved at the same time, i.e. this leads to economical benefit. When the profitability of a company is high, benefit is achieved immediately. However, investment buys off also for the case when profit is not immediately noticed.

The majority of small and medium-sized companies invest in personnel safety and health reluctantly, i.e. the owners of the companies consider this investment as cost, i.e. loss, that is attempted to avoid thereof. The loss of small and medium-sized companies related to personnel safety and health is "paid" by the workers themselves and public, i.e. the state.

The economical benefit of investment to occupational health and safety could be computed according to the recommendations of Finish scientists (Jurvansuu *et al.* 2000; National Safety Council 2000). They have determined that in low and medium-size construction companies, investment to human health and safety retrench losses three times. This computation, in their opinion, is quite accurate. Thereinafter, economical benefit assessment made according to these recommendations is given.

According to data from construction companies, these are spending approximately 443 LTL of investment to occupational health and safety. In 2007, there were 108.5 thousands of employees in construction companies. The total costs of construction companies regarding occupational health and safety during year 2007 were LTL

48.1 millions (443x108500), or about 0.44 percent of construction work volume.

If the companies increased their finances by 0.5 percent of construction work volume and devoted to occupational health and safety, construction companies would increase their profit by LTL 19.5 millions.

### 4. Conclusions and Recommendations

For the period 2002–2009, in the construction sector, 4136 workers were injured, 413 of which seriously and 193 were killed. During this period, the major part of the accidents occurred due to falls from height and made 839 cases.

Approximately 55% of the accidents occur in building companies where the number of personnel varies from 50 to 249. In the majority of cases, workers experience accidents during their first year at work. The workers at the age from 35 to 54 experience injuries most often. Approximately 25% of seriously injured and approximately 40% of killed workers felt drunk during an accident.

The main reasons for the accidents are non-compliance with requirements for legal regulations and inappropriate work planning. Other significant reasons cover a lack of knowledge and training as well as understanding safe implementation of the assigned work and the carelessness and negligence of workers. Unsafe behaviour is one of the factors leading to accidents at work and this shows a poor safety culture in a company.

The biggest economic losses are stemming from falls from height (about 22%, 2006), the violation of safety and health acts at work (about 73%, 2007), the insobriety of workers (about 11%, 2003 and 2004) and short work experience (one year) (about 53%, 2007). This affects a lack of discipline, a lack of workers' control in organizations and minimum investment in improving working conditions. The existing problems have a negative impact on the country's economic development because of high social insurance and accident benefits.

Nationwide loss due to work accidents that occurred in building companies per year decreased from LTL 37.8 millions in 2002 to LTL 25.7 millions in 2009. For the period 2002–2009, the amount of loss reached LTL 398.6 millions.

For the period 2002–2009, the GDP part of LTL 35.0 millions was not produced due to the accidents that occurred in the construction sector. The amount used for the benefits of social insurance fund was LTL 54.7 millions, and loss due to fatal accidents reached LTL 167.8 millions within the period concerned.

The amount of the loss of building companies due to accidents at work increased from LTL 4.2 millions (in



2002) to LTL 11.7 millions (in 2007), and in total, for the period 2002–2007, made LTL 42.7 millions.

It is necessary to improve the preparation of technology projects for construction works, because the situation created during the preparation of technology projects for construction works is not satisfactory. Therefore, these projects are not prepared and the prepared projects are not detailed, finished and concrete. The workers who should work according to the prepared projects are not informed about their content.

Work planning is the main factor directly influencing accidents at work. In this case, the role of personnel safety and health coordinators as well as contractors and subcontractors is very important.

Designers, construction managers, supervisors, planning and carrying out building tasks must assess the risks associated with work at heights and to provide and implement security measures to protect workers from falls from height. Coordinators must participate in the preparation and implementation of technical design.

Workers must participate in the risk estimation process. An employer/a worker must understand how to complete every assignment safely. During risk estimation, it is necessary to foresee all dangers, especially when the sequence of works planned in construction design changes.

Employers, after risk estimation, must take means of precaution by considering the existing dangers, including ones appearing during work. Attention, mainly, must be paid to works at height, to the workers working their first year, to the prevention of drinking and to work planning. The personnel must be trained and instructed about risk.

Employees with less than one year seniority should be granted probation in order to better understand health and safety requirements at work. It is very important for small and medium-sized companies.

Construction companies must take more stringent measures for inebriation cases. The employer must verify the employee's sobriety before starting work and during working hours.

Considering the results of estimating professional risk, conditions for personnel safety and health, financial availabilities and market situation and competition, the companies have to prepare plans for implementing safety and health requirements, schedule deadlines and allocate the required fund and create a personnel encouragement system towards the improvement of safety and health. Especially economically valuable decisions are those improving work planning.

Using the resources of the social insurance fund for prevention from accidents at work is very important for small and medium-sized companies. In 2006, only two building companies used this resource.

It is important to oblige an employer to allocate a particular part of resources to object estimates from the overall tender prices to secure personnel safety and health. It is necessary to introduce a special tendering procedure (by improving the Public Procurement Law) where the winner would be selected not only according to the lowest proposed price, but also according to the secu-

rity of personnel safety and health on the construction site.

The employer, in order to ensure the safety of workers should promote the employees. While promoting staff, it is useful to remember that money is not the most important aspect taken by people. Accolade, award, prize, access training or free Friday – all these are excellent ways of promotion, especially if applied according to particular needs of employees.

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## EKONOMINIAI NUOSTOLIAI DĖL DARBUOTOJŲ SAUGOS IR SVEIKATOS REIKALAVIMŲ NEUŽTIKRINIMO LIETUVOS STATYBOS SEKTORIJE

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Santrauka

Socialinės apsaugos ir darbo ministerijos užsakymu (sutartis Nr. 2594-AP) atliktas tyrimas *Ekonominiai nuostoliai (pasekmės) dėl darbuotojų saugos ir sveikatos reikalavimų neužtikrinimo statybos sektoriuje 2002–2007 m.* Šiame moksliniame tyrime, atlikus darbuotojų saugos ir sveikatos būklės analizę statyboje ir išnaginėjus nelaimingų atsitikimų darbe ekonomines pasekmes, investavimo į darbuotojų saugą ir sveikatą ekonominę naudą, pateikti tyrimo rezultatai, išvados ir rekomendacijos. Tai padės sumažinti profesinių ligų ir nelaimingų atsitikimų darbe skaičių ir bus išvengta ekonominių nuostolių tiek valstybei, tiek statybos įmonėms.

**Reikšminiai žodžiai:** sauga ir sveikata darbe, nelaimingi atsitikimai darbe, ekonominiai nuostoliai, statybos sektorius.

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