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# Impact of social safety investments on social costs of construction accidents

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Most contractors' financial losses associated with accidents, but not all, are also social costs. Some social costs are not incurred by contractors, but by society. Social costs of construction accidents have been gathered for years 1999–2001. The safety investments made by both contractors and society are also identified based on data assembled for these three years. These social costs and safety investments were identified from 119 construction projects involving 1414 accidents and from 18 government departments in Hong Kong. The data shows that there was an increasing trend in social safety investments and a decreasing trend in social costs of construction accidents from 1999 to 2001. During this period, for every extra \$1 of social safety investments made, a reduction of \$2.27 of social costs on construction accidents was achieved in Hong Kong.

**Keywords:** Safety, costs, investments, social impact, construction, accidents, Hong Kong

## Introduction

The financial costs borne by contractors due to construction accidents have been a hot topic for many years, and its related works have been reported for several decades ago by researchers such as H.W. Heinrich, a pioneer on the subject since the 1940s/1950s, with his latest publication (Heinrich *et al.*, 1980), then Leopold and Leonard (1987), Lee (1991), Levitt and Samelson (1993), Everett and Frank Jr (1996), Tang *et al.* (1997) and Hinze (2000). The last two works – Hinze (2000) and Tang *et al.* (1997) – were in fact very similar. In Hinze's work, he detailed the formulae used for calculating accident financial losses based on the US situation in general. He also used two examples, a small project and a large project, to illustrate how to invest in safety, and suggested the concept of plotting two cost curves (injury cost curve and safety investment cost curve) in relation to the level of effort

on safety. The work by Tang *et al.* (1997) included not only the detailed calculations of accident financial losses and safety investments for construction projects based on Hong Kong's situation, but also the plotting of the two curves as suggested by Hinze for determining the minimum level of safety investments that contractors should make, which was found to be 0.8% of the contract sum.

To summarize previous studies, the financial costs of a construction accident include: (1) loss due to the injured person's absence from work; (2) loss due to the injured person's inefficiency after resuming work; (3) medical expenses; (4) fines and legal expenses; (5) loss of time of other employees; (6) equipment or plant loss; (7) loss due to damaged material or finished work; (8) loss due to idle machinery or equipment; and (9) other losses (Tang *et al.*, 1997).

Unlike financial costs studies, however, previous investigations related to social costs are found to be very few. Hinze and Appelgate (1991) reported a respectable work on detailed figures of direct and indirect costs of

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construction injuries and calculated the ratio of these two categories of costs. The direct and indirect costs identified in this work, and particularly the indirect costs, covered many aspects of costs related to construction accidents, but were still mostly financial as considered in the context of this current work. Ngai and Tang (1999) attempted to compare the differences of financial costs and social costs and to discover what the social costs of construction accidents are. The current work takes a further step, i.e. to evaluate the social costs borne by the society of Hong Kong due to the occurrence of construction accidents and the related social safety investments. In this study, social costs are reckoned as the costs incurred by the society because additional resources are required to be utilized when construction accidents occur. If there were no accidents, the utilization of these society's resources could have been saved.

The objectives of this paper are to: (1) identify from a list of contractors' financial losses, based on the previous work of Tang *et al.* (1997), what financial losses are also social costs and what are not; (2) identify other social costs borne by the society that are not contractors' losses; (3) identify social safety investments in the construction industry; (4) gather cost data on those identified in objectives 1, 2 and 3 in Hong Kong for years 1999, 2000 and 2001; and (5) analyse the data gathered and establish a relationship between the social safety investments and the social costs of accidents for the construction industry in Hong Kong.

### Social costs of construction accidents

There are basic financial cost items that a contractor will incur when a construction accident occurs. These items have been detailed in the research paper by Tang *et al.* (1997) as mentioned earlier. Table 1 is a reproduction of these items from that research paper. The figures/numbers and the formulae given in the table have been explained in the said paper and are not to be explained again here.

'Day loss' in item 1 of Table 1 is important in calculating social costs. The social cost due to 'day loss' of the victim is calculated by: daily wage of the victim  $\times$  day loss (i.e. days absent from work). If the accident involves permanent disability of the victim, then the social cost due to the permanent disability will be calculated by daily wage  $\times 365 \times (\text{retire age } 65 - \text{injury age}) \times \% \text{ disability}/100$ . The daily wage is calculated by dividing the monthly salary by 30 (because, in this equation it is multiplied by 365 days/year), as workers are usually paid on a monthly basis in Hong Kong. As an example, if a worker who earns HK\$600 a day (HK7.8 = US\$1) is absent from work for seven calendar days, and is

certified by a doctor to be of 2% permanent disability as a result of the accident which occurs when the victim is of age 34, then the social cost will be:

$$(\text{HK\$}600 \times 7) + [\text{HK\$}600 \times 365 \times (65 - 34) \times 2/100] = \text{HK\$}4200 + \text{HK\$}135\,780 = \text{HK\$}139\,980$$

If an accident is a fatal case, then the social cost will be calculated by: daily wage  $\times 365 \times (\text{retire age } 65 - \text{death age})$ . The compensations paid by the employer (contractor) to the injured worker (employee) for both day loss and disability, as shown in item 1 of Table 1, are not counted as social costs because they are 'transfers' (Tang, 2003) and therefore only financial but not social.

Item 2 in Table 1 is a financial loss of contractor, which is also a social cost. This item concerns with the loss due to the injured worker after return to work. For the time immediately after resuming work, the worker cannot work with 100% efficiency. The formula for calculating such loss is daily wage  $\times (\text{day loss} \times 1/10 + \% \text{ disability})$ . The formula is based on the assumption that the severity of 1% disability is equivalent to that of an injury resulting in a loss of 10 working days in inefficiency after resuming work. This assumption is quite subjective, but has been used in the previous study: formula (1) in Tang *et al.*'s (1997) paper. In this current study, the authors will use the same formula. As an example, if a worker who earns HK\$600 a day was absent from work for 7 days, and was certified to be of 2% permanent disability, then the loss will be:

$$\text{HK\$}600 \times (7 \times 1/10 + 2) = \text{HK\$}1620$$

Item 3 concerns medical expenses. As explained in Tang *et al.*'s (1997) paper, a contractor is obligated to pay for the injured worker HK\$68 a day for hospitalization, which is heavily subsidized by the Hong Kong Government. The actual cost is HK\$3062 per day (information provided by the Hong Kong Hospital Authority). The former (HK\$68) is a financial cost while the latter (HK\$3062) is a social cost. In this paper, the purpose is to find social costs and, therefore, HK\$3062 per day is used for calculating the social cost of hospitalization. Some injured workers may not require hospitalization, and their medical expenses (other than hospitalization) are still social costs, and are separately considered in the data gathering exercise.

In item 4, fines are not social costs because they are transfers rather than real costs. Transfers do not involve the utilization of the society's resources but real costs do (Tang, 2003), although the former are financial losses of contractors. Fines therefore do not count for calculating social costs, although they may have distributional effects in society but this is not the primary concern of the current study. Solicitor fees, however,

**Table 1** Contractor's losses due to occurrence of a construction accident

Cost items arising from each construction accident			
Project no.: _____		Accident date: _____	
1. Injured person (job nature: _____)		Age _____ yrs.	
		Gender _____	
– Day Loss		_____ Days	
– Amount of Compensation		HK\$ _____	
– % of Disability		_____ %	
– Disability Compensation		HK\$ _____	
2. Loss from injured person (after resuming work)			
– Equivalent loss = (Day Loss × 1/10) + % of Disability		_____ Days	
– Loss = Equivalent Loss * (Wage HK\$ _____/day)		HK\$ _____	
3. Medical services and expenses			
– Hospitalization/medical expenses		HK\$ _____	
– Others (e.g. transportation costs, etc.)		HK\$ _____	
4. Fines and legal expenses			
– Fines by court		HK\$ _____	
– Solicitor fees		HK\$ _____	
– Others		HK\$ _____	
5. Lost time of other employees (Time taken by other employees in assisting the injured person immediately after accident)			
<i>Post</i>	<i>Monthly wages</i>	<i>Time incurred</i>	
– Site Agent	HK\$ _____	0.05 Day	HK\$ _____
– Site Engineer	HK\$ _____	0.05 Day	HK\$ _____
– Site Foreman	HK\$ _____	0.25 Day	HK\$ _____
– *Other Labourers	HK\$ _____	1 Day	HK\$ _____
6. Equipment or plant loss			
– Damaged/replacement cost		HK\$ _____	
– Repairing cost		HK\$ _____	
– Others		HK\$ _____	
7. Damaged material or finished work			
– Cost of damaged material		HK\$ _____	
– Cost of damaged finished work		HK\$ _____	
– Others		HK\$ _____	
8. Idle machinery/equipment			
**Idle machinery/equipment		HK\$ _____	
9. Other costs items			
– _____		HK\$ _____	
<b>TOTAL</b>		HK\$ _____	

\*(Four workers) × (1/4 days) × (daily wage of injured person); \*\* (contract sum × 20%) × 2% / (no. of total working days for the contract).

are both financial and social costs and must be taken into account in evaluating social costs. Items 5, 6, 7 and 8 in Table 1 are all both financial and social costs. They contribute to the calculation of the social costs of construction accidents.

Besides the above-mentioned items, other costs borne by the society must be considered. Five government departments in Hong Kong incur expenses due to the occurrence of construction accidents. They are the Fire Services Department, Hong Kong Police Force, Social Welfare Department, Legal Aids Department and Court. The portions of the expenditures of these five departments related to construction accidents have to be found and included in the social cost calculation.

There is a sixth one, the Hong Kong Hospital Authority, which incurs expenses when construction accidents occur. The Hospital Authority spends a large sum of money on the hospitalized injured workers, as it spends HK\$3062 per day to hospitalize a person, as mentioned earlier in this paper. Since the total hospitalization expenditure is a substantial sum of money, as compared to that spent by the other five government departments, it is therefore singled out and presented separately in the evaluation of social costs.

Moreover, the time lost by the victim's relatives (and friends also) should be considered too. Their time spent in connection with the accident is a social cost, because they may have lost time from their livelihood and

yielded a decreased production/contribution to the society. It is not an easy task to estimate this social cost. Two formulae have been assumed after consultation with experienced social workers. The first formula is for non-fatal accidents and the losses of relatives are calculated by  $\text{daily wage} \times (\text{day loss} + \% \text{ disability} \times 10)$ . The factor 10 in this formula is consistent with the assumption previously mentioned. As an example, if a worker who earns HK\$600 a day was absent from work for seven calendar days, and was certified to be of 2% permanent disability, then the social cost (due to losses of relatives) will be:

$$\text{HK\$}600 \times (7 + 2 \times 10) = \text{HK\$}16\,200$$

The second formula is for fatal accidents and the losses of relatives are calculated by:  $\text{daily wage} \times \text{age factor} \times 7 \text{ days} + \text{HK\$}20\,000$ . The last term HK\$20 000 is the average funeral related costs. The age factor (as suggested by the social workers consulted) is given by:

<i>Age</i>	<i>Age factor</i>
16–26	1.2
26–35	1.8
36–45	2.1
46–55	2.3
56–65	2.5

The older the age, the higher the age factor is. This is because the number of relatives (and friends) increases when one's age increases, and hence the losses of relatives increase.

### Social safety investments in construction

Safety investments made by society in the construction industry are defined as the sum of two components. The first component is the resources on safety invested by contractors in construction projects and the second component is the resources invested by government departments (Ngai and Tang, 1999). Safety investments made by contractors include investments in safety administration personnel on construction sites and at head-offices, safety equipment, safety training and promotion provided by contractors (see Table 2). Safety investments made by the government include investments in safety administration personnel employed in relevant government departments, and the safety training and promotion provided by these departments. In the past six or seven years, the Hong Kong Government has launched huge schemes for improving construction safety, such as the Pay For Safety Scheme (PFSS) (Hong Kong Government, 1996a) implemented since 1996, the Independent Safety Audit Scheme (ISAS) (Hong Kong Government, 1996b) implemented since 1997, and the Safety Supervision

Plan Scheme (Hong Kong Government, 1998) implemented since 1998. The social safety investments made by the society of Hong Kong have increased considerably in recent years.

Thirteen government departments in Hong Kong contribute parts of their expenses to social safety investments in construction. They are the Occupational Safety and Health Council, Construction Industry Training Authority, Vocational Training Council, Industrial Centre of the Hong Kong Polytechnic University, Labour Department, Housing Authority, Water Supplies Department, Building Department, Territory Development Department, Drainage Services Department, Civil Engineering Department, Architectural Services Department and Highways Department. All these departments commit resources, whether large or small, to the prevention of construction accidents. They have been approached by this study for acquiring the social safety investment data.

### Data gathering exercise

In this exercise, data on 119 construction projects in Hong Kong were acquired. They included both building and civil engineering projects, and were selected from a number of reputable contractors in Hong Kong, the data collected from which were believed to be reliable. It may be argued that 'reputable' contractors may have a better safety record than the other contractors in Hong Kong, thus distorting the results. Nevertheless, more safety conscious contractors tend to maintain better records, thus capturing more costs than what the other contractors may do. Therefore, there is a compensating effect. It is the safety conscious companies that often favourably consider requests for surveys such as this study.

Figure 1 shows the distribution of the contract values and the number of accidents for the 119 projects studied, where there were a total of 1414 accidents – six of which were fatal and 426 of which involved permanent disability. Table 2 is the questionnaire which contractors were asked to fill in the itemized safety investments on the project, the contract period from when (month/year) to when (month/year), the contract sum, etc. As there are 119 projects involved in this study, 119 summary sheets have been completed by the contractor's project managers for these projects. Similarly, 1,414 sheets of the Table 1 form have also been completed because there were 1414 accidents involved in these 119 projects. From these forms, the authors were provided with sufficient information to calculate the social costs incurred and the social safety investments made by the contractors, as were described in the previous sections of this paper. The social cost and safety investment data obtained from these 119 construction projects were

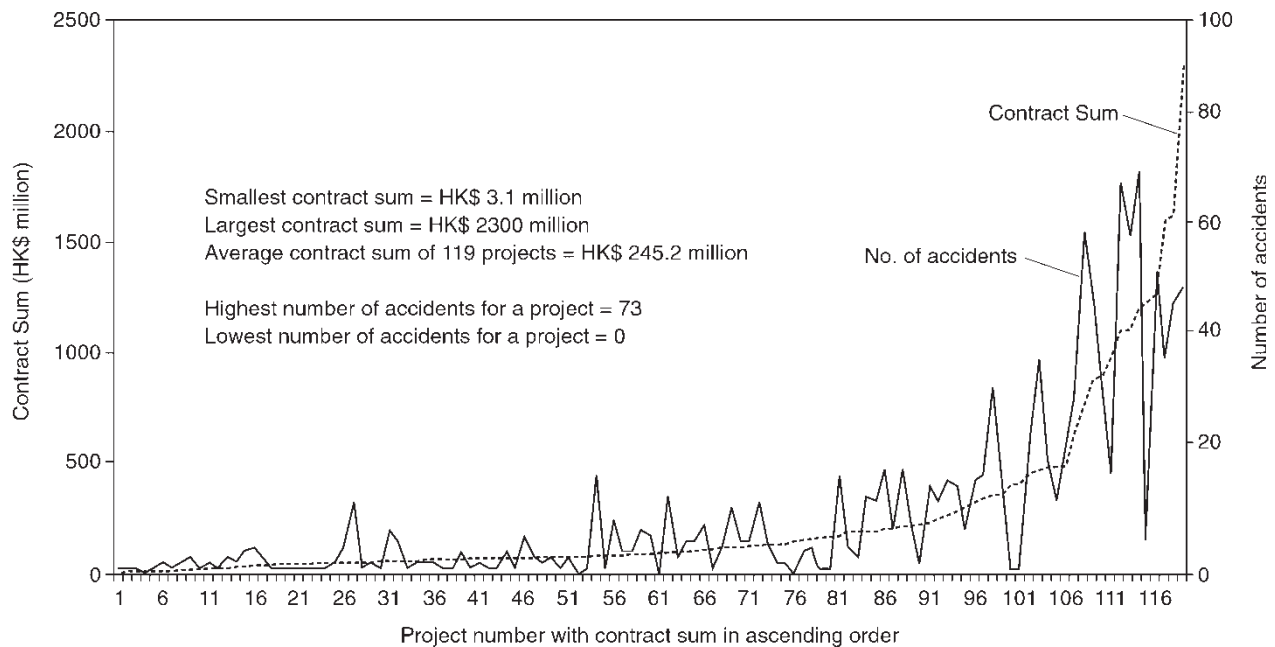


**Table 2** Information on each construction project and its safety investments

## Project safety investment information

Project No.: \_\_\_\_\_

1. Contractor: _____		
2. Contract Title: _____		
3. Contract Sum (Including V.O.): _____		
5. Contract period: _____ to _____		
6. Number of Working Days: _____		
7. Total man-days employed (including subcontractors) _____		
8. Number of Accidents: _____		
9. Number injured: _____ Number dead: _____		
10. Investment on safety administration personnel		
10.1 On-site module		
Post	Number	Monthly wage
Safety officer	( )	HK\$ _____
Safety supervisor	( )	HK\$ _____
Secretary/typist/clerk	( )	HK\$ _____
Others: _____	( )	HK\$ _____
10.2 Head-office module		
Post	Number	Monthly wage
Safety manager	( )	HK\$ _____
Chief safety officer	( )	HK\$ _____
Senior safety officer	( )	HK\$ _____
Secretary/typist/clerk	( )	HK\$ _____
Others: _____	( )	HK\$ _____
11. Investment on safety equipment for the project _____		
12. Safety training cost _____		
13. Safety promotion cost _____		
14. Other costs		
i. _____		HK\$ _____
ii. _____		HK\$ _____
iii. _____		HK\$ _____
<b>TOTAL</b>		HK\$ _____

**Figure 1** Distribution of contract values and number of accidents

separated into three time periods: years 1999, 2000 and 2001.

The method of separating the contract sums, the safety investments and the accident costs into the three time periods can be illustrated by an example. The example is taken from one of the 119 actual construction projects considered. This project had a contract sum of HK\$2,300 million and lasted for 24 months, of which four months fell in 1999, 12 months in 2000 and eight months in 2001. Then, HK\$383.33 million (i.e. HK\$2300 million  $\times$  4/24) was put in the year 1999 contract sum category. Using the similar proportioning method, HK\$1,150 million and HK\$766.67 million were put in the years 2000 and 2001 contract sum categories respectively. The contract sums of the other 118 projects were also treated in the same way. The same method was used in separating the contractors' safety investments of these 119 projects. It may be argued that it is better to use the actual cost S-curves of the projects. However, it was not possible to obtain the S-curves of all the 119 projects. Another important reason for not using S-curve effects is that the sample size of 119 projects is quite large. The distributional effect of S-curves should have disappeared for such a sample size, like the concept of central limit theorem in statistics, when *sample size*  $\geq 30$  (Berenson and Levine, 1989, pp. 297–9).

For accident costs, the method of separation was different but still simple. For the construction project under consideration, 49 accidents occurred during the 24 months contract period, with 12 in 1999, 21 in 2000 and 16 in 2001. The social costs of the accidents were therefore separated according to the actual dates of the accident occurrence and not by proportioning as was done for contract sums and safety investments.

The total contract sums of the 119 projects, split into three years, are shown in Table 3. They represent 10.03673%, 10.42127%, 10.87303% of the total construction outputs in Hong Kong in years 1999, 2000 and 2001 respectively (construction output is the total value of all construction work carried out during that fiscal year. The figures are published by the Census and Statistics Department, Hong Kong). The annual total construction outputs can be found from the 'Works Digest', a publication of Hong Kong Government (2001). The total safety investments of the 119 projects made by the contractors for these three years are shown in Table 4. These figures are derived from items 10, 11, 12, 13 and 14 of the 119 forms (Table 2). For social costs due to contractors' losses, medical expenses (non-hospitalization cases), hospitalization expenses, losses of victims and relatives for these 119 projects, they are shown in Table 5 for the respective years. These social

**Table 3** Total yearly contract sum of 119 projects against yearly total construction output

	Year 1999	Year 2000	Year 2001
Total contract sum of 119 projects	HK\$10 019 674 392	HK\$9 654 273 557	HK\$9 502 380 185
Total construction output in Hong Kong	HK\$99 830 000 000	HK\$92 640 000 000	HK\$87 394 000 000
Percentage representing total construction output	10.03673%	10.42127%	10.87303%
Total man-days	946,332	872,872	835,016

**Table 4** Total safety investments made by the contractors of the 119 projects

	Year 1999	Year 2000	Year 2001
Total safety investments made in the 119 projects	HK\$81 157 384	HK\$84 411 270	HK\$88 923 939

**Table 5** Total social costs of 119 projects

	Year 1999	Year 2000	Year 2001
Total number of accidents occurred	540	487	387
Total number of hospitalization days	2023	1998	1737
Social costs due to contractors' losses	HK\$5 654 533	HK\$4 274 755	HK\$3 411 085
Social costs due to medical expenses (non-hospitalized)	HK\$439 284	HK\$425 092	HK\$215 751
Social costs due to hospital expenses	HK\$6 194 426	HK\$6 117 876	HK\$5 318 694
Social costs due to losses of victims	HK\$44 523 316	HK\$28 664 713	HK\$18 262 171
Social costs due to losses of relatives	HK\$22 198 902	HK\$16 926 227	HK\$14 905 617
Total social costs incurred in the 119 projects	HK\$79 010 461	HK\$56 408 663	HK\$42 113 318

costs are derived from the 1,414 forms (Table 1): social costs due to contractors' losses are derived from items 2, 4, 5, 6, 7, 8 and 9; medical expenses and hospitalization costs are derived from item 3; losses of the victim and relatives are derived from item 1.

There are 18 questionnaires designed for the 18 government departments, 13 of which contribute investments to construction safety and five (excluding Hospital Authority) of which incur expenses in construction accidents. It is impossible to show the

readers 18 questionnaires. Only one of them, the questionnaire for OSHC (Occupational Safety and Health Council), is shown in Table 6 in order to give the readers an idea how the questionnaire looks and what data are acquired. The social safety investments made by the 13 departments are shown in Table 7. The social costs borne by the five departments are shown in Table 8. The individual safety investment made or social cost borne by each department is not shown for confidentiality at the request of those government departments.

**Table 6** Sample questionnaire to governmental organizations investing on safety

Questions	Year 1999	Year 2000	Year 2001
(1) The number of persons employed for implementing <i>construction</i> safety course			
a) Full-time lecturer	_____ no.	_____ no.	_____ no.
b) Part-time lecturer	_____ no.	_____ no.	_____ no.
c) Instructor	_____ no.	_____ no.	_____ no.
d) Clerk/typist	_____ no.	_____ no.	_____ no.
e) Others: _____	_____ no.	_____ no.	_____ no.
_____	_____ no.	_____ no.	_____ no.
(_____ % of time, if not 100%, is spent on implementing <b>construction</b> safety course)	_____ no.	_____ no.	_____ no.
(2) Average number of hours per person per month spent by those staff in (1) for construction safety training:			
a) Full-time lecturer	_____ hrs.	_____ hrs.	_____ hrs.
b) Part-time lecturer	_____ hrs.	_____ hrs.	_____ hrs.
c) Instructor	_____ hrs.	_____ hrs.	_____ hrs.
d) Clerk/typist	_____ hrs.	_____ hrs.	_____ hrs.
e) Others: _____	_____ hrs.	_____ hrs.	_____ hrs.
_____	_____ hrs.	_____ hrs.	_____ hrs.
_____	_____ hrs.	_____ hrs.	_____ hrs.
(3) Average hourly salary per person:			
a) Full-time lecturer	HK\$ _____	HK\$ _____	HK\$ _____
b) Part-time lecturer	HK\$ _____	HK\$ _____	HK\$ _____
c) Instructor	HK\$ _____	HK\$ _____	HK\$ _____
d) Clerk/typist	HK\$ _____	HK\$ _____	HK\$ _____
e) Others: _____	HK\$ _____	HK\$ _____	HK\$ _____
_____	HK\$ _____	HK\$ _____	HK\$ _____
_____	HK\$ _____	HK\$ _____	HK\$ _____
(4) Total promotion costs borne by OSHC on <i>construction</i> safety:	HK\$ _____	HK\$ _____	HK\$ _____
(5) Total Operating Costs of OSHC (excluding staff salaries and promotion):	HK\$ _____	HK\$ _____	HK\$ _____
(_____ % spent on construction safety related expenses)	HK\$ _____	HK\$ _____	HK\$ _____
(6) Other costs related to <i>construction</i> safety, not covered above	HK\$ _____	HK\$ _____	HK\$ _____

(The sample given is the questionnaire sent to the Occupational Safety and Health Council (OSHC), Hong Kong.)

**Table 7** Total social safety investments made by the 13 government departments

	Year 1999	Year 2000	Year 2001
Total social safety investments made by the 13 departments	HK\$79 293 997	HK\$92 082 210	HK\$91 602 581



**Table 8** Total social costs incurred by the five government departments

	Year 1999	Year 2000	Year 2001
Total social costs incurred by the five departments	HK\$1 003 332	HK\$908 086	HK\$647 040

### Impact of social safety investments on social costs

The values of safety investments and social costs in Tables 4 and 5 have to be proportioned to the overall yearly value by using the percentages they are representing as shown in Table 3. The calculations are shown in Tables 9 and 10, which show the overall social safety investments and the overall social costs respectively in each of the years.

The overall social safety investments and the overall social costs for year 1999 have to be expressed as percentages of total construction output in that year. The same has to be done for years 2000 and 2001 also. These are shown in Table 11, and a pictorial presentation of which is shown in Figure 2.

Table 12 shows the differences of these percentages between 1999 & 2000 and 2000 & 2001. The two

values, the reduction in social costs divided by the increase in social safety investments for 1999 vs. 2000 and 2000 vs. 2001 respectively, can then be calculated, and the mean value of which is \$2.27. This means that for every extra \$1 of social safety investments made during 1999 to 2001, a reduction of \$2.27 in social costs of construction accidents can be achieved in Hong Kong.

### Conclusion and suggestion for further work

In this study, relevant data as to the social costs and social safety investments identified from 119 construction projects involving 1414 accidents and from 18 government departments in Hong Kong were gathered. The impact of social safety investments on reducing social costs was evaluated. There has been an increasing

**Table 9** Calculation of overall yearly social safety investments

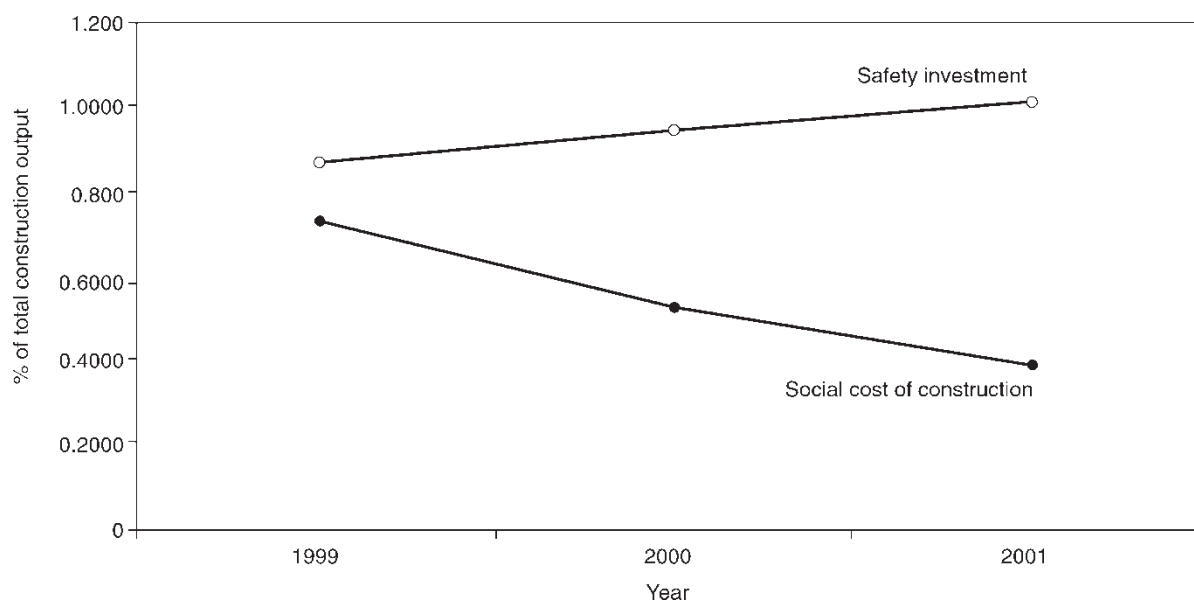
	Year 1999	Year 2000	Year 2001
Yearly social safety investments excluding those made by the 13 government departments	81 157 384/0.1003673 = HK\$808 603 289	84 411 270/0.1042127 = HK\$809 989 484	88 923 939/0.1087303 = HK\$817 839 177
Yearly social safety investments made by the 13 government departments	HK\$79 293 997	HK\$92 082 210	HK\$91 602 581
Overall yearly social safety investments	HK\$887 897 286	HK\$902 071 694	HK\$909 441 758

**Table 10** Calculation of overall yearly social costs

	Year 1999	Year 2000	Year 2001
Yearly social costs excluding those incurred by the five government departments	79 010 461/0.103673 = HK\$787 212 651	56 408 663/0.1042127 = HK\$541 283 473	42 113 318/0.1087303 = HK\$387 318 903
Yearly social costs incurred by the five government departments	HK\$1 003 332	HK\$908 086	HK\$647 040
Overall yearly social costs	HK\$788 215 983	HK\$542 191 559	HK\$387 965 943

**Table 11** Overall social costs and overall social safety investments as percent of total construction output

	Year 1999	Year 2000	Year 2001
Total construction output	HK\$99 830 000 000	HK\$92 640 000 000	HK\$87 394 000 000
Overall social costs	HK\$788 215 983	HK\$542 191 559	HK\$387 965 943
Overall social costs as percent of total construction output	0.7896%	0.5853%	0.4439%
Overall safety investments	HK\$887 897 286	HK\$902 071 694	HK\$909 441 758
Overall safety investment as percent of total construction output	0.8894%	0.9737%	1.0406%



**Figure 2** Graphical presentation of overall social costs and overall social safety investments as a percentage of total construction output of each year

**Table 12** Reduction of social costs as a result of one extra HK dollar increase of social safety investments

	Year 1999 vs. Year 2000	Year 2001 vs. Year 2001
Reduction in overall social costs (% of total construction output)	$0.7896 - 0.5853 = 0.2043$	$0.5853 - 0.4439 = 0.1414$
Increase in overall social safety investments (% of total construction output)	$0.9737 - 0.8894 = 0.0843$	$1.0406 - 0.9737 = 0.0669$
Reduction in social cost divided by increase in safety investment	$0.2043/0.0843 = 2.4235$	$0.1414/0.0669 = 2.1136$
Mean value	$(2.4235 + 2.1136)/2 = 2.27$	

trend in social safety investments and a decreasing trend in social costs, and for every extra \$1 of social safety investments made, a reduction of \$2.27 of social costs on construction accidents was achieved in Hong Kong in the three years under study.

It can be seen from the result that for every extra \$1 of social safety investments, the reduction of social costs is \$2.4235 (1999 vs. 2000) and is \$2.1136 (2000 vs. 2001). The figure (2.4235 or 2.1136) can be called a *social cost reduction to safety investment increment ratio*. There is a decreasing trend for this ratio from 1999 to 2001. We forecast that the decrease will continue for a number of years ahead. This is a reasonable forecast because further increase in safety provisions will not reduce accident costs limitlessly, according to the 'law of diminishing returns' of economics theories. A time in the future may come when every extra \$1 of social safety investment will result in \$1 of reduction of social costs, that is, when the 'social cost reduction to safety investment increment ratio' becomes 1. If this happens, the 'optimum point' will have been reached. Hence,

continuation of this research to keep track of the development of social safety investments made and the social costs incurred in the Hong Kong construction industry in the years ahead is recommended. The data revealed may be used as a reference for policy decisions of the Government to determine the adequacy of social safety investment in Hong Kong, and it is advisable for the Government to maintain records of those figures in the years ahead.

In this work, only the time costs of the injured persons and their relatives have been considered. Pain and suffering costs of persons and other costs or damages associated with human feelings have not been included. We believe that these costs are a significant component to social costs of construction accidents, but are not easy to relate in monetary terms. If they were also considered, the reduction of social costs could be higher than \$2.27 per extra \$1 of social safety investments, as calculated in this paper. Therefore, further research should be carried out in this important area. The social

costs due to losses of relatives, although using the formulae derived after consultation with social workers, also need refinement. These losses would also vary according to the type of relatives (e.g. the spouse or parent might lose more than, say, a brother or sister). We think that there is room for improvement and further work should be done in this respect.

Although the results are relevant to Hong Kong only, the method can be applied to other countries/cities. The concept of social cost reduction to social investment increment ratio can be applied elsewhere other than Hong Kong, and a government may formulate its own construction safety policies by reference to such a ratio.

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