Singapore Institution of Safety Officers

JAN / MAR 2020

safety matters

MAKING THE DIFFERENCE IN SAFETY
PERMIT NO: MCI (P) 140/03/2019

Simple Way To Save Lives In Low-Falls

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Fig. 1. (a) Fatal fall from canopy, (b) Fatal fall through formwork gap

Look at the two pictures of Singapore case studies in Figure 1.

(a): "Worker fell 3 m from canopy …";

(b): "worker fell through gap in formwork ... and succumbed to his injuries". This means he did not survive.

Falling from heights between 2 m and approximately 6 m has happened half a dozen times in Singapore over the last few years. The reasons attributable to the falls were mainly due to fragile roofs and ceilings, formwork gaps and roof and floor openings. As the falls were typically onto the ground or lower floors, these invariably resulted in deaths.

The many lives lost meant that many sons, brothers and fathers were plucked away from their families in the prime of their lives. Certainly, many of them could have been saved from unnecessary death.

Let us examine how.

The Problem

We are not talking about the entire phenomenon of falling from heights. The risk is as old as time, ever since man learned to walk on two legs. The potential to falls will continue with the inexorable pull of gravity on anything and everything that goes up and becomes unsupported. Even the most technologically advanced countries in the world have quite high fatality rates for falling from heights.

No, we are talking about a very special subset of the problem of falling from heights in the range from 2 m to about 6 m — the range within which fall protection is essential but full body safety harness will not be effective in preventing the body from crashing to the ground.

The minimum of 2 m comes from the worldwide understanding and acceptance of the fact that except for rare freak events, an adult falling at level or from within 2 m would not suffer major injuries or die.

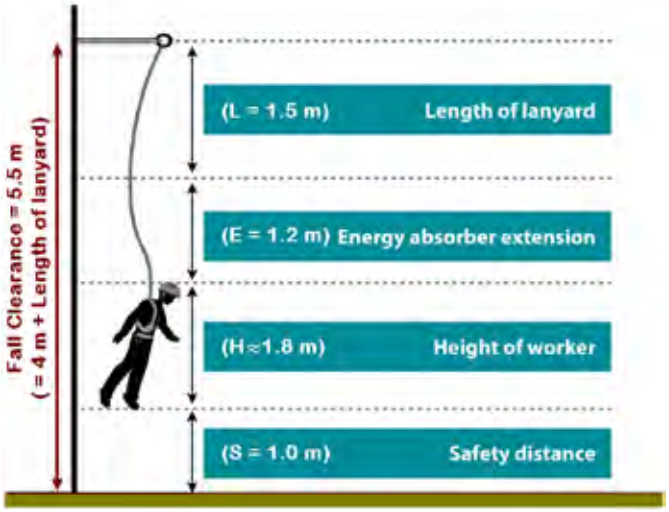

Fig. 2. Fall Clearance for Safety Harness

The maximum of 6 m or so comes from the need for fall clearance for the shock absorber of the safety harness to deploy and serve as a stopping distance, to lower the impact force at the end of the fall. (Refer to Figure 2.)

Figure 2 is adapted from the Singapore Code of Practice for Working Safely at Height (source: Reference 1). The author prefers to define the fall clearance value as 4 m plus the length of lanyard rather than the specified 5.5 m, so that Lanyards longer than 1.5 m may be accommodated.

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This is where the problem lies.

Most canopies, and most residential and office building floors are more than 2 m high but less than about 6 m high. The same goes for the second floors of most buildings, the top of shipyard containers, mobile elevating work platforms operating at low levels, etc. These are therefore hazardous to the workers involved. Let us refer to this range of 2 to 6 m as our 'Low-Fall' range.

We cannot, and should not, issue safety harnesses in these cases, but unfortunately, many employers do, with good intentions but having failed to check their effectiveness. If the workers with safety harness fall and the shock absorber does not deploy, then the victims may become paralysed if they crash on their rump, or die if they land on their head.

Safety harnesses also demand certain other co-requisites for their effective operation such as strong anchors (as summarised by the author in Reference 2) which cannot easily be met in the situations under discussion.

So, what do we do?

Hierarchy of Fall Management

The universal approach to fall management is based on the following two premises:

(i) Prevention of fall is better than stopping a fall before hitting the base. The latter is referred to as fall 'protection' or fall 'arrest' in many countries; and

(ii) Collective control is better than individual control with personal protection equipment (PPE).

Based on these premises, the hierarchy of fall control is as follows, from the most effective to the least effective:

1. Collective Prevention: Guard-rail or other edge protection
2. Individual Prevention: Work restraint, and work positioning
3. Collective Protection: Soft landing, e.g. nets, cushions
4. Individual Protection: Full body safety harness

Author usually represents this as the matrix in Figure 3, as in Reference 3.

Sad to say, many contractors jump from Option 1's (edge protection) to Option 4's (safety harness) when guard-rails could not be provided (and sometimes, in addition to guard-rails!).

Fig. 3. Fall Control Hierarchy Matrix

Actually, all four options are listed and described in the Code of Practice [source: Reference 1]. The industry however has not taken well to Options 2 and 3, often due to lack of awareness.

Against this background, we can easily see that for low-fall problems, Options 1 and 2, namely edge protection and work restraint/positioning may not be practical or convenient. That logically brings us to Option 3, namely soft landing.

Soft Landing: Nets

Soft landing is exactly what it says: Let the worker land softly at the end of his fall. There are many ways to provide this soft landing, which in effect should catch the worker at the end of his fall and slow him down to a stop over a certain length and time so that there will be no shock to his body causing injury.

The first obvious choice is a net.

Trapeze artistes all over the world have been using it all the time, as at left in Figure 4. Joseph Strauss, Chief Engineer for the Golden Gate Bridge in the early 1930s, was the first to use safety nets to catch people falling from the bridge during construction, as shown at right in Figure 4, with the finished bridge and engineer Strauss in its inset.

Fig. 4. (Left) Net for circus trapeze; (Right) Net for Golden Gate Bridge

Fig. 5. (Left) Net in Steel Erection; (Right) Fallen worker caught in net.

In most of the West and Australia among other countries, nets are commonly used to catch falling workers in high-rise construction, as depicted in Figure 5. In fact, it is standard practice in most advanced countries for steel erection to have safety nets immediately under the work area.

Regrettably, most of the time, nets are used in Singapore to serve more as catch nets for debris during construction, rather than to catch falling workers.

In any case, nets may not be convenient for low-falls due to the need for four or more anchors for erecting the nets, and the requirement for sufficient deflection space below them. Nets may also be deemed inconvenient due to the time and effort required to plan, erect and remove them.

The simpler and better alternative to nets for soft landing will be cushions. They can be laid on a flat horizontal surface to receive the falling body, protecting it from damage.

Soft Landing: Cushions

Cushions are solid and made of polystyrene or other foam materials. Due to their bulk, they will not be convenient for transportation, frequent shifting around or for ad-hoc use in general situations. As such, foam-filled cushions are restricted to long-term stationary use.

Hence the most common cushion for temporary fall protection is the air-bag.

As a matter of fact, the air-bag is the most-often used soft landing in many countries for different purposes. The air-bag has been used through many decades successfully.

Air-bags are most commonly used for low-fall construction work, typically from one floor to the next floor, dispensing with any further fall prevention or protection measures or PPE, as shown in Figure 6.

Fig. 6. Air-bags in general, concrete, and timber construction

Air-bags are routinely used to rescue victims of fire or other disasters trapped in higher floors, and to protect workers from fall injuries while working on sloping roofs or while loading and unloading trucks. (Refer to Figure 7)

Fig. 7. (Left) Fall from sloping roof; (Right) Truck loading and unloading

Olympic and other international sports event organisers use air-bags to rescue people trapped in lower floors. Moreover, air-bags of very large sizes are used in the training for various hazardous tasks and hobbies such as skiing, and sports such as gymnastics (Refer to Figure 8).

They are the most common fall control for stunts in movies and TV shows.

Interestingly enough, air-bags are also a popular sport in Western countries, where ordinary people of all ages pay to jump from heights from 5 m or more, onto air-bags, just for the fun of it, for the thrill of it. (Middle and Right, Figure 8.)

Fig. 8. (Left) For Olympic ski training; (Middle and Right) Just for the fun of it!

None of these applications seem to have found a place in Singapore, in the construction industry or any other industry with low-fall hazards.

The one silver lining in this cloud is the routine use of the air-bag by the Singapore Civil Defence Service (SCDF).

It deploys a standard air-bag or 'Life-Pack' ('Air Pack - 100') for most of their rescue missions of people stranded in low rise floors, to foil suicides, and to avoid an escaping criminal jumping from a mid-height floor and badly or fatally injuring himself.

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They also have larger air-bags to cushion falls from high floors. The left part of Figure 9 shows the SCDF air-bag laid out ready for inflation, and the right part shows the bag fully inflated, in one of their emergency rescue missions.

Fig. 9. (Left) SCDF air-bag ready for inflation; (Right) Fully inflated.

With such extensive use of the soft landing by a government agency, it is really a pity that local industries have not adopted it for their own safety improvement!

Application to Construction Low-Falls

On the basis of the preceding, it should be clear that the air-bag would be the ideal solution to manage low-falls from canopies, formwork and other work in the 2 to 6 m range.

It does not take too much stretch of the imagination to visualise that the simple act of strategically placing a few air-bags under the canopy or other low-fall situations would provide the requisite soft landing for any worker who happens to fall from his perch.

The uninflated size of the air-bag bundle will be 5% to 10% of the inflated size of the air-bag, and hence it can be easily transported and shifted around. A small capacity diesel pump should suffice to inflate it, although on occasion even a hand-pump has been found adequate for small bags.

Let us see how the air-bags could have prevented the fatalities as shown on Figure 1, using illustrations from Figure 10. The images show the same two cases of canopy and formwork as in Figure 1, this time with a few air-bags strategically placed under the fall hazard zone. (The illustrations without air-bags are intentionally blurred and shown alongside those with air-bags, for comparison purposes.)

Fig. 10. Fall without and with air-bags from (a) canopy and (b) through formwork gap. (Outside figures, without air-bags, purposely blurred.)

It is clear that what turned out to be death-traps could have been miraculously turned into a life-saving situation, with the simple insertion of a few air-bags!

To dispel any doubts if any untoward harm might happen when a person falls on an air-bag, it should be pointed out that the typical air-bag for soft landing will not be designed in such a way that any object falling on it will bounce back. This is unlike a trampoline or a spring supported surface, which might land the victim from one disaster to another.

There will be vents on the sides which will bleed out the air gradually when an object impacts the surface, providing a sinking surface which will absorb the kinetic energy without impact or shock. The fallen person will be enveloped around his body and brought to rest with no damage, pain, or even discomfort.

Design and Cost Considerations

Of course, there will be some design for the air-bag. However, design would be important more for the larger bags and higher jumps, which would be well beyond the low-fall scenarios we are discussing in this paper.

For our purposes, commercially available gymnastics-rated air-bags should be quite adequate, as the manufacturers would have provided for the impact of falling human bodies over the height ranges we are concerned with. These may be good even for falls up to 8 or 10 m.

A good reference point would be the SCDF usual air-pack, roughly 3 m by 5 m by 2 m tall.

It is difficult to find their exact costs online.

Figure 11 may be used as a benchmark for preliminary calculations.

Fig. 11. Typical air-bag details

It appears that SG$80-100 per sq. m. may be a good rate for estimating purposes.

The author opines that a convenient size for ease of transportation and shifting around would be 1.5 m by 2 m, which might cost about $250, and would weigh around 25 kg.

> *Safety isn't expensive, it's priceless*

Investing one time in, say a dozen of them, for $3,000, would permit a coverage of 36 sq. m, variable from a 6 m square to a rectangle of 12 m by 3 m, which should accommodate most canopies and formwork, and also enough to go around a 40 ft (12 m) long container or other object. Adjacent air-bags may be inter-connected by straps and buckles so as to act integrally.

They can be reused many times, with some care during laying and movement.
With an investment of $3,000, how many lives can be saved and major injuries avoided!

Surely even a single life would be worth this kind of money?

Recommendations

The author believes that he has made a strong case for Singapore construction and other hazardous industries to immediately start using air-bags for fall protection of personnel in the low-fall range where safety harnesses could not be used.

Singapore Code of Practice for Working Safely at Height [Ref. 1] states in 12.3.4, in part:

"If a person is required to work on or from a roof that is fragile and can break easily, it is important to ensure that:

- *An adequate fall arrest system is installed and used;*
- *Other measures that can be effectively deployed to reduce the distance of a potential fall, for example, safety net."*

Workplace Safety and Health (Work at Height) Regulations 2013 also recommends the safety net, but not the air-bag for fall arrest.

Singapore Standard SS292: 1984 gives the Specification for Safety Nets for Construction Sites, but does not seem to have found much application in the industry.

This should cover the scenario we have been discussing, under the announced principle of the WSH Act: *'The WSH Act marks a shift from the prescriptive legislative approach under the Factories Act, to a performance-based regime.'*

Obviously, nothing prevents us from starting from this directive and using the alternative method of soft landing offered by the air-bag instead of the net.

However, much of Singapore's industries, particularly SMEs, still look up to MOM/WSHC for any and every new initiative. The author wishes that WSHC had gone into more details in the working at height Code and added 'or air-bag' after mentioning nets, so that the industry could have used the air-bag much earlier.

Even now, an advisory or a guidebook on this topic may be very effective.

Over the last decade and a half while the author has been lecturing extensively on working safely at height, he has consistently been emphasising, and urging his course participants and consultancy clients, to go for this air-bag solution. He illustrated his case with slides such as Figs. 1 and 10.

He has even offered to assist them in start-ups and implementation … but he has had no takers.

Some frankly explain their reluctance to adopt his suggestion, with the argument that if the air-bag had been so useful, MOM would have said so!

It is heart-breaking to see lives lost when the solution is staring us in the face!

Merely urging safety teams to do a better risk assessment would not suffice to solve the problem. The industry knows the risk. What they need is firm guidance towards a practical, effective solution: in this case, the air-bag.

The author hopes that with the explanatory background and practical details he has provided in this paper (and a nudge from MOM, which has already been doing a monumental job of improving workplace safety!) pro-active individuals and companies will take up this simple air-bag solution to a vexing problem, and start saving life and limb!

Low-level falls cannot be avoided – but deaths from them can be!

References

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