Assessment of Knowledge & Awareness among the Professionals Regarding the Concept of Safety by Design

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ABSTRACT

Purpose: *Recently safety by design is widely used globally in the design phase of the project itself as a proactive approach to safety management. so the overall objective of this research is to assess the knowledge & awareness among Nepalese professionals regarding the concept of Safety by Design.*
Design/Methodology/Approach: *The study covers a systematic review of a wide range of papers using content analysis followed by a scheduled questionnaire survey. Constructivism philosophy of research was used. Piloting assures the quality of five ranking Likert scale questionnaire before the survey. ANOVA test was used to analyze the response collected. Cronbach's alpha assures reliability and literature comparison assures validity.*
Findings/Result: *Most of the design professionals have heard of SbD from 2011 to 2020 during the college only as satisfactory to a good understanding. Understanding of the Clients was found to be satisfactory whereas that of Contractors and Engineers in abroad was having good understanding. They rarely get to address the worker's health and safety during the design phase even after realizing high importance. Lack of sufficient guidelines, manuals, online resources, or other materials that facilitate using of the SbD approach was found. Limited knowledge regarding SbD was considered as the most important factor that restricted the use of SbD in the construction industry. Also, no regulatory provisions and designer's limited experience were the ones to restrict the use of SbD. Regarding the factors contributing to the success of SbD, design professionals agreed that legislative force is the most important factor followed by tools and guidelines related to SbD. Apart from them engaging the SbD experts and support from industry are equally important for the success of SbD.*
Originality/Value: *It is action research. This study helps in motivating and creating awareness among the design professionals working not only in transmission lines but also to study and use the concept of safety by design in their respective fields to eliminate the hazards.*
Paper Type: *Ex-Post Facto Research*
Keywords: Expertise, Factors, understanding, culture, guidelines

1. INTRODUCTION :

Design is mother of construction that is why it is obvious to expect safety from design as a child expect safety from mother. Designing is extensive work of a group of professional as multidisciplinary action to assure constructability safely in excellent way without distinguishing white- and blue-collar jobs. The best and strong method for establishing a solid and safe work space is to wipe out perils and dangers during the plan of new plant, constructions, substances and innovation and of occupations, cycles and frameworks. This plan interaction needs to consider perils and dangers that might be available at all phases of the lifecycle of constructions, plant, items and substances [1]. Endeavours to work on the adequacy of Health and Safety frameworks by utilizing undeniable level gamble controls carried out at

the plan stage are alluded to in different ways, for example, 'safe design', 'prevention through design (PtD)', 'safety in design', 'safety by design' and 'design for construction safety' [2].

All things considered, originators have not customarily tended to development worker safety and regularly don't know about the degree to which their plan choices sway development safety. Development occupational safety is ordinarily disregarded until the beginning of the development stage. A typical issue architect notice is that they miss the mark on preparing to address specialist wellbeing. Some battle that they don't have the foggiest idea how to change their plans to improve or guarantee security, and that there is no focal assemblage of information accessible to help them in perceiving wellbeing dangers and altering their plans to limit or dispose of the perils. A few originators have likewise expressed that, to limit their responsibility openness, they purposely try not to address development occupational safety.

As proprietor worries about development specialist wellbeing increment, it is guessed that fashioners, as well as project workers, will be all the more intensely associated with guaranteeing security later on. While the mechanics for expanded association of workers for hire in wellbeing are grounded, little data exists on how creators can be involved undeniably. Maybe the job of planners in development security can be best worked with by the amassing of an assortment of information about plans that emphasis on development wellbeing. A plan instrument or help would assist planners with being all the more completely informed about the manners by which they can further develop specialist security. The wellbeing thoughts could then be fused straightforwardly into the plan period of a venture [3].

2. PROBLEM STATEMENT :

Safety of construction site can be improved assuming that a plan cycle is all around built as far as development wellbeing moderation. Originators including modelers, designs and related specialized specialists, should give a high need to somewhere safe by plan. By tending to the security issues during the plan interaction, dangers can be disposed of or decreased during development. So, prior to applying the idea of wellbeing by plan essentially architects need to know exhaustively about it. Till date practically every one of the works connected with security by configuration has been led in the part nations of the European Union, Australia and the United States. The idea of wellbeing by configuration is not really observed to be drilled in the Nepal and other Asian nations. Subsequently it is important to survey the information and attention to the plan experts with respect to the idea of security by plan.

3. OBJECTIVES :

The overall objective of this research is to assess the knowledge & awareness among the professionals regarding concept of Safety by Design in Burtibang Paudi-Amarai Tamghas Sandhikharka Gorusinghe 132 kV Transmission Line Project.

4. LITERATURE REVIEW :

Wellbeing by plan otherwise called Safe plan is a course of coordinating the control estimates from the get-go in the plan interaction, to kill or limit dangers of injury over the development and lifetime of a venture [4].

In development, the idea of wellbeing in plan is characterized as the thought of building site security in the plan of a task. In particular, this incorporates adjustments to the long-lasting elements of the development project so that building site wellbeing is thought of; consideration during the readiness of plans and determinations for development so that building site security is thought of; the usage of explicit plan for development wellbeing ideas; and the correspondence of dangers with respect to the plan comparable to the site and the work to be performed [5].

Table 1: Literature Review

S.N.	Title of paper	Country	Characteristics and focused area	Published on /By	Year of Publication
1	"Safety in Design"	Australia	Identifies design as having the potential to reduce the risk of accidents in construction	Helen Lingard Payam Pirzadeh James Harley Nick Blismas Ron Wakefield	2014 [2]

2	"Linking construction fatalities to the design for construction safety concept"	USA	Established a clear link between construction fatalities and the design for construction safety concept	Michael Behm	2005 [5]
3	"Structural Steel Design, Education Module"	USA	Introduction to Prevention through Design with examples of Ptd	NIOSH	2008 [6]
4	"Practice of safety culture principles"	Nepal	Focus on safety culture to be followed and enshrined by the various project stakeholders in all the phases of the project life cycle	Anjay Kumar Mishra Khem Raj Joshi	2020 [7]
5	"Addressing construction worker safety in the design phase Designing for construction worker safety"	USA	Accumulation of suggestions for improving construction worker safety while in the design phase	John A. Gambatese Jimmie W. Hinze	1999 [8]
6	"Australian Work Health and Safety Strategy 2012–2022"	Australia	Promotes the vision of healthy, safe and productive working lives	Safe Work Australia	2012 [1]
7	"Safe design of structures, Code of Practice"	Australia	An approved code of practice to achieve the standards of health, safety & welfare required under WHS Act & Regulations.	Safe Work Australia	2012 [4]
8	"Safety In Design In Construction: An Introduction"	New Zealand	Helps in understanding the basics of safety in design, so that anyone's health and safety is not at risk	Site Safe New Zealand	2019 [9]
9	"Viability of Designing for Construction Worker Safety"	USA	Investigate the practice of addressing construction worker safety when designing a project and to determine the feasibility and practicality of such an intervention	John A. Gambatese Michael Behm Jimmie W. Hinze	2005 [10]
10	"Health and safety in the construction industry:	UK	Exploration and consolidation of knowledge on underlying causes of	Charlotte Brace Alistair Gibb Martyn Pendlebury Philip Bust	2009 [11]

	Underlying causes of construction fatal accidents – External research"		accidents and approaches to prevent accidents, determined by parties outside of HSE		
13	"Designing for safety: perspectives from European union, United Kingdom, Australia and United States pertaining to safety and health in construction"	Pakistan	Study the history of 'design for safety' in member countries of EU, UK, Australia and USA that provide guidance for others to pursue and adopt	Rafiq M. Choudhry Helen Lingard Nick Blismas	2009 [12]
14	"Tool to design for construction worker safety"	USA	Improve women's quality of life through the use of improved energy technologies	John A. Gambatese Jimmie W. Hinze Carl T. Haas	1997 [3]

5. RESEARCH GAP :

Several studies of risk level have been conducted, operational status have been analyzed (Mishra, 2021) [13], job safety analysis have been done (Mishra and Aithal, 2021) [14] and found different hazards (Lama et al, 2019) [15] with great urge to improve the safety status effectiveness (Mishra et al, 2019) [16], however, no study regarding safety by design for transmission line project have been done yet though the project seems to be risky. This action research will be first of its kind in global literature, however, an urge to early engagement have been globally focused.

6. RESEARCH METHODOLOGY :

6.1 Study Area

BPTSG Project starts from Motipur, Kapilvastu to Burtibang, Baglung in two different sections namely Motipur-Sandhikharka section and Sandhikharka-Burtibang Sections. The length of Motipur-Sandhikharka Sections was around 38 Km and Sandhikharka-Burtibang was around 47.5 Km in length. BPTSG also included five substations located at Motipur (Kapilvastu), Sandhikharka (Arghakhanchi), Tamghas (Gulmi), Paudi-Amarai (Gulmi) and Burtibang (Baglung) for the collection and evacuations of electric power generated within the Uttarganga River and other different Hydropower project located nearby to the National Grid. BPTSG passes through four different districts Namely Kapilvastu, Arghakhanchi, Tamghas and Baglung District.

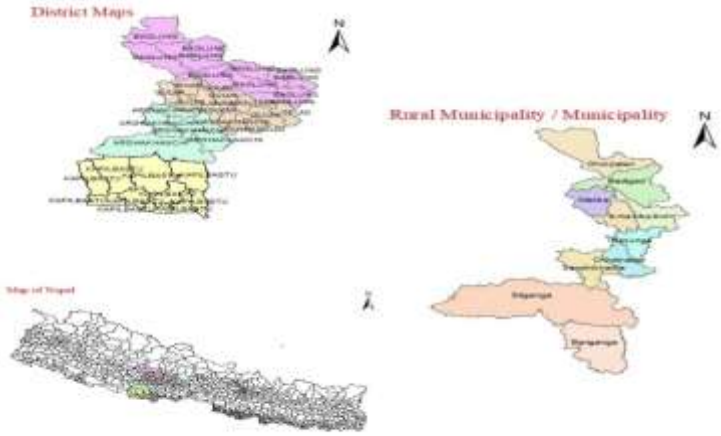

Fig. 1: Study Area

6.2 Primary Data:

Strength of a Study depends upon data quality which is highly maintained as follows:

Observation Checklist: To identify the safety status of the site and different occupational hazards, observation checklist as well as questionnaire was used. The implementation of the safety procedures was checked by preparing the observation checklist.

Key Informant Interview: The Key informant interviews (KII) of the transmission line experts was taken for the validity and reliability of the studies. The KII was based on the snowball sampling.

Questionnaire Survey: Different set of questions was prepared regarding concept of safety by design, its implementation as well as safety implemented at the site of BPTSG 132 kV TLP. The questionnaires were distributed to the Clients, Contractors, Workers and Other design professionals for questionnaire Survey. It was done through physical presence after taking appointments through emails.

6.3 Secondary Data:

Secondary data was collected from the literature study of national and international articles, published journals, reports and internet/websites about the concept of safety by design and its implementation in the construction industry.

6.4 Analysis of Data:

Computer software such as MS Excels and SPSS software package was used for the derivations of the data and the logically interpreted outcomes was presented in tables. MS Excel was used to calculate sample size, Reliability Test, Chi-square Test and Kendall rank correlation coefficient. Similarly, SPSS was used to calculate Reliability Test, Descriptive Statistics (means, frequency tables & charts), ANOVA and Ranking of factors/hazards.

7. RESULTS AND DISCUSSION :

Overall, from the questionnaire administration, 70 responses were received. The 70 respondents include 3 Engineers from Clients, 4 Engineers from Contractors, 6 Engineers from Nepal but working in abroad and 57 Engineers working in different sectors in Nepal.

7.1 Basic Knowledge Assessment among Professionals Regarding SbD:

Familiarity with the term SbD i.e., heard of SbD or not, when and where did the respondents heard of SbD was assessed.

A. Familiarity with the term SbD:

It was found that 94.29% of the respondents have heard of SbD. The 5.71% of respondents that haven't heard of SbD were from the experience group 6 to 10 years of Other Professionals. So, it can be concluded that majority of respondents have heard of SbD and the term was not as new as thought before the study.

B. Time frame when SbD was heard:

Among those who have heard of SbD, 74.24% of them have heard about SbD during a period of 2011 to 2020 and 18.18% of them have heard during 2001 to 2010. From the literature review, it was clear that the concept of SbD has come into existence during early 1990 s and research are being made till date. So, the concept is relatively new in the construction industry and most of the respondents have heard about it in recent years.

C. Place of learning SbD:

Regarding the place where SbD was learnt, a majority of 65.15% of respondents have learnt about SbD through college as a part of curriculum, 21.21 % through the company they work in and 10.61% through self-study. So, this shows that SbD has been included in the course of study and it is really important that this should be practiced by the design professionals in the construction field.

7.2 Knowledge and Awareness of Professionals regarding SbD:

A. Perception regarding importance of SbD:

The respondents were asked regarding their perception about the importance of SbD, to which 77.27% of respondents have responded that SbD is very important whereas 22.73% responded that it is important. This shows that all of the respondents have agreed that SbD is a must in the construction filed.

B. Role of designer in improving safety status

It was found that a clear majority of 93.94% respondents have agreed that the designers play an important role in improving the safety status of a construction site. This is because designers are the final implementer of SbD and they incorporate the health and safety provisions during the design phase itself. Incorporating safety provisions in design phase is the most effective way to eliminate/control the hazards occurring in the site.

C. SbD included in professional duty:

It was found that 98.48% of respondent agreed that their professional duty should involve designing for safety to minimize the hazards as it is the earliest and cheapest means to eliminate/control the hazards. This clearly indicates that the respondents are eager to accept the SbD approach and use them in their professional field.

D. Effectiveness of SbD to improve injuries and fatalities rate:

It was found that 92.42% respondents have agreed that SbD will improve the injuries and fatalities rate in the construction industry because it prevents hazards from occurring in the first place and minimizes the risks if not prevent it completely.

E. Early contractor involvement:

In response to the question whether early contractor involvement is essential or not for SbD, 60.60% of respondents have responded yes, whereas 39.40% of them have responded no or may be. This gives a clear indication that the respondents do not have sufficient knowledge about the SbD.

F. Responsibility for ensuring the Clients are aware of SbD:

60.61% of respondents have responded that Designers are responsible whereas 27.27% have responded Contractors are responsible for ensuring that Clients are aware of SbD. The responses to this question were fair in terms of knowledge regarding the SbD.

G. Training on SbD:

In response to the question regarding whether or not the respondents have received any training related to SbD, 71.21% responded that they haven't received any training on SbD whereas 28.8% responded they have received the training on SbD. So, it can be concluded that majority of respondents have not received the training on SbD as it is relatively new concept.

H. Address worker's safety in design phase:

It was found that that 34.85% of respondents are rarely to never involved, whereas 33.33% are involved sometimes. Only 31.82% are involved often to always.

I. Availability of guidelines and manuals:

The respondents were asked if the available guidelines, manuals and other resources are sufficient or not, to which 53.03% have responded that the available guidelines, manuals and other resources are insufficient to very insufficient whereas 18.18% remains neutral. Only 28.79% thinks they are sufficient.

J. Beginning stage of SbD:

A question about the stage in which SbD should begin was asked, to which 65.15% have responded Planning and designing phase whereas 33.33% have responded Initiation phase. This clearly shows that the respondents have very little knowledge about SbD as from the concept of SbD and section 2.7.2 of literature review, it is clear that SbD begins right through the Initiation phase.

K. Final implementer of SbD:

The respondents were asked regarding who the final implementer of SbD is, to which only 27.27% have responded Designers are the final implementer whereas 72.73% have responded other. This clearly show that the respondents lack the basic knowledge about the SbD thereby making it necessary to aware the design professionals regarding the SbD.

7.3 ANOVA Test:

ANOVA test was conducted to analyze if there was significant difference in the means for different respondents group for following four questions:

1. Perception on importance of SbD
2. Understanding of SbD
3. Address Construction worker health and safety in design phase

4. Availability of sufficient guidelines, manuals and online resources for SbD

Hypothesis

Null Hypothesis (Ho): There is no significant difference in the means for different respondents group.
Alternative Hypothesis (H1): There is significant difference in the means for different respondents group.

Table 2: One Way ANOVA Test Results

	Test of Homogeneity of Variance		ANOVA	
Question	**Levene Statistic**	**Sig**	**F**	**Sig**
Perception on importance of SbD	6.011	.001	1.210	.313
Understanding of SbD	5.342	.002	1.191	.321
Addressing Workers safety and health in design phase	3.154	.031	.658	.581
Availability of Sufficient guidelines, manuals	3.519	.02	.914	.440

The Table 2 above shows that there was no significant difference in the means for different respondent groups i.e. (F 3, 62 = 1.21, p = .313), (F 3, 62 = 1.191, p = .321), (F 3, 62 = .658, p = .581) and (F 3, 62 = .914, p = .440) respectively.

7.4 Likert Scale Analysis:

Likert scale analysis was also conducted for same four set of questions. The mean is very significant in Likert scale. The Table 2 above also shows the mean values of response for different groups.

Table 3: Mean value for Likert scale analysis

Questions	Clients	Contractors	Er. In Abroad	Other Professionals	Other Professionals		
					Exp. <= 5 years	Exp. 6 to 10 years	Exp. > 10 years
Perception on importance of SbD	4.67	4.5	5	4.77	4.8	4.79	4.5
Understanding of SbD	3	3.75	3.83	3.45	3.5	3.34	4
Address workers health & safety in design phase	2	3.25	3	2.92	2.6	3	4
Availability of design Guidelines, manuals and online resources	2	2.75	3.17	2.74	2.7	2.76	2.75

Table 4: Mean range and their responses for 5 point Likert scale [17]

Mean Range	Responses			
1 to 1.79	Very Unimportant	Very Poor	Never	Very Insufficient
1.80 to 259	Unimportant	Poor	Rarely	Insufficient
2.60 to 3.39	Quite Unimportant	Satisfactory	Sometimes	Neutral
3.40 to 4.19	Important	Good	Often	Sufficient
4.20 to 5.0	Very Important	Excellent	Always	Very Sufficient

The mean values for perception on importance of SbD implementation were 4.67 for Clients, 4.5 for Contractors, 5 for Engineers in abroad and 4.77 for Other Professionals. The mean for all four groups lies in between 4.20 to 5. From the Table 3 above, it is clear that the range 4.20 to 5 indicates very important thus it can be concluded that majority of participants thinks that implementation of SbD is very important. Also, the mean value is highest for the Engineers in abroad, which indicates SbD is given more importance in construction practices of abroad. Comparing the mean values for different experience groups, it can be seen that respondents with less than equal to 10 years of experience have given more importance than those having experience more than 10 years.

Also, when the respondents were asked about their level of understanding regarding SbD, it was found that the mean values were 3 for Clients, 3.75 for Contractors, 3.83 for Engineers in abroad and 3.45 for Other Professionals. From the Table 3 above, it is clear that the range 2.60 to 3.39 indicates the level of understanding as satisfactory whereas range 3.40 to 4.19 indicates the level of understanding as good. So, it can be concluded the understanding level of Clients was satisfactory whereas that of Contractors, Engineers in abroad and Other Professionals were good. This shows that Client's understanding on SbD is lower compared to others. The mean value is highest for the Engineers in abroad, which indicates that SbD is quite familiar in abroad and understanding of Engineers in abroad was quite higher than others. Also, for other professionals, the mean value was highest for the group with experience more than 10 years indicating more the experience better is the understanding.

In response to a question regarding if the respondents have ever been asked to address "Construction worker health and safety" in the design phase, the mean of responses were 2 for Clients, 3.25 for Contractors, 3 for Engineers in abroad and 2.92 for Other Professionals. From the Table 3 above, it is clear that the range 1.80 to 2.59 indicates rarely addressing worker's safety in design phase whereas range 2.60 to 3.39 indicates addressing worker's safety in design phase sometimes. So, it can be concluded that the Clients are rarely involved in addressing the worker's safety during the phase whereas Contractors, Engineers in abroad and Other Professionals were sometimes involved in addressing the worker's safety during the phase. The mean is lowest for Clients indicating that Clients are the least involved in addressing the safety issues in design phase. The results are discouraging as Clients are involved in approving the design and that they can ask designers to incorporate the safety measures in design phase. Comparing the means of Other Professionals, it was found that mean values increase along with the experience which means more the experience, more they get chance to address the worker's safety in the design phase.

The mean of responses for question regarding whether there are sufficient safety by design guidelines, manuals, online resources or other material or not to facilitate planning was found to be 2 for Clients, 2.75 for Contractors, 3.17 for Engineers in abroad and 2.74 for Other Professionals. From the Table 3 above, it is clear that the range 1.80 to 2.59 indicates that the resources are insufficient whereas range 2.60 to 3.39 indicates that the respondents are not sure about the availability of resources. So, it can be concluded that the Clients thinks that the availability of guidelines, manuals, online resources or other material are low and insufficient whereas Contractors, Engineers in abroad and Other Professionals remain neutral to whether the resources available are sufficient or not. The mean value is higher for the Engineers in abroad indicating that resources are quite easily available in abroad however they are not actively involved in SbD, so they have chosen to be neutral on this regard.

7.5 Ranking the Values Based on Mean

The respondents were asked to rank the factors with 1 indicating the most important factor. Since the lowest number is used to rank the most important factor, the factor with least mean value shall be the most important factors. Kendall's coefficient of concordance was performed for the analysis of ranking data. Kendall's coefficient of concordance is used for determining the degree of association among several (k) sets of ranking of N objects or individuals. Kendall's coefficient of concordance (W) is considered an appropriate measure of studying the degree of association among three or more sets of rankings [18]. We have $\bar{R}j = \frac{\Sigma Rj}{N}$ and $W = \frac{s}{\frac{k^2(N^3-N)}{12}}$ which are used in calculations below.

Table 5: Critical values of s at 5 % level of Significance

k	N					Some additional values for $N = 3$	
	3	4	5	6	7	k	s
3			64.4	103.9	157.3	9	54.0
4		49.5	88.4	143.3	217.0	12	71.9
5		62.6	112.3	182.4	276.2	14	83.8

Kendall's coefficient of concordance has been conducted for three questions i.e., Rank the factors that assist to carry out SbD, Rank the factors that restricts the use of SbD and Rank the factors that contribute to the success the SbD.

Factors assisting to carry out SbD: There are several factors (listed in the Table 5 below) that assist to carry out SbD. As there are four sets of rankings, the coefficient of concordance (W) was calculated for judging significant agreement in ranking by different respondents. For this purpose, the given matrix as Table 5 below was developed.

Table 5: Matrix of Factors That Assist to Carry Out SbD

k = 4	Factors assisting to carry out SbD					
Respondents	Training courses	Pictorial representation	Online forum	Mobile application	Videos	N = 5
Clients	1	3	4	5	2	-
Contractors	1	3	4	5	2	-
Er. in abroad	1	2	3	3	4	-
Other Professionals	1	2	3	5	4	-
Sum of Ranks (R_j)	4	10	14	18	12	Σ Rj = 58
$(R_j - \bar{R}j)^2$	57.76	2.56	5.76	40.96	0.16	s = 107.2

The value of W calculated is 0.67. To judge the significance of this W, value of s was determined from the Table 5 at 5% level for k = 4 and N = 5. This value was 88.4 which is lower than 107.2 i.e., W = 0.67 is significant. Hence, the null hypothesis was rejected and it was concluded that the different groups of respondents were applying essentially the same standard in ranking the N factors i.e., there was significant agreement in ranking by different groups of respondents at 5% level in the given case. The lowest value observed amongst Rj is 4 for training courses and as such training courses can be determined as the most important factor of all followed by pictorial representation, videos online forum and mobile application the least important factor based on values of sum of ranks (Rj).

The ranking of factors by different groups of respondents are given in the Table 6 below.

Table 6: Ranking of Factors That Assist to Carry Out SbD

Respondents		Factors	Training courses	Pictorial representation	Online forum	Mobile application	Videos
Clients		Mean	1.67	2.33	4.33	4.67	2.00
		Rank	**1**	**3**	**4**	**5**	**2**
Contractors		Mean	1.75	3.5	3.75	4	2.00
		Rank	**1**	**3**	**4**	**5**	**2**
Er. in abroad		Mean	1.67	2.83	3.33	3.33	3.83
		Rank	**1**	**2**	**3**	**3**	**4**
Other Professionals		Mean	1.57	2.68	2.98	4.06	3.72
		Rank	**1**	**2**	**3**	**5**	**4**
Other Professionals	Exp. <= 5 years	Mean	1.5	3	2.75	4.15	3.6
		Rank	**1**	**3**	**2**	**5**	**4**
	Exp. 6 to 10 years	Mean	1.55	2.41	3	4.14	3.9
		Rank	**1**	**2**	**3**	**5**	**4**
	Exp. > 10 years	Mean	2	3	4	3	3
		Rank	**1**	**2**	**5**	**4**	**3**

From the Table 6 above, it can be seen that all the groups of respondents have ranked training courses as the most important factor, so training can be considered as the best way to make design professionals aware of SbD.

Factors restricting the use of SbD: There are several factors (listed in the Table 7 below) that restricts the use of SbD. These factors were ranked based on Kendall's coefficient of concordance method to study if the ranking was done consistently or not.

Table 7: Matrix of Factors That Restricts the Use of SbD

k = 4	Factors restricting the use of SbD					
Respondents	Limited knowledge	Designer's fear of liability	Designer's limited experience	Increased designer's cost	No regulatory provisions	N = 5
Clients	1	5	2	4	3	
Contractors	1	4	5	3	2	
Er. in abroad	1	4	3	5	2	
Other Professionals	1	2	3	5	4	
Sum of Ranks (R_j)	4	15	13	17	11	Σ Rj = 60
$(R_j - \bar{R}j)^2$	64	9	1	25	1	s = 100

The value of W calculated is 0.625. To judge the significance of this W, value of s was determined from the Table 5 at 5% level for k = 4 and N = 5. This value was 88.4 which is lower than 100 i.e., W = 0.625 is significant. Hence, the null hypothesis was rejected and it was concluded that the different groups of respondents were applying essentially the same standard in ranking the N factors i.e., there was significant agreement in ranking by different groups of respondents at 5% level in the given case. The lowest value observed amongst Rj is 4 for limited knowledge and as such limited knowledge can be determined as the most important factor of all followed by no regulatory provisions, designer's limited experience, designer's fear of liability and increased designer's cost the least important factor based on values of sum of ranks (Rj).
The ranking of factors by different groups of respondents are given in the Table 8 below.

Table 8: Ranking of factors that restricts the use of SbD

Respondents		Factors	Limited knowledge	Designer's fear of liability	Designer's limited experience	Increased designer's cost	No regulatory provisions
Clients		Mean	1.33	4.33	2.33	3.67	3.33
		Rank	**1**	**5**	**2**	**4**	**3**
Contractors		Mean	2.25	3.5	3.75	3	2.5
		Rank	**1**	**4**	**5**	**3**	**2**
Er. in abroad		Mean	1.83	3	2.83	4.83	2.5
		Rank	**1**	**4**	**3**	**5**	**2**
Other Professionals		Mean	2	2.83	3.11	3.6	3.45
		Rank	**1**	**2**	**3**	**5**	**4**
Other Professionals	Exp. <= 5 years	Mean	1.85	3.1	2.9	3.55	3.6
		Rank	**1**	**3**	**2**	**4**	**5**
	Exp. 6 to 10 years	Mean	2.1	2.69	3.24	3.55	3.41
		Rank	**1**	**2**	**3**	**5**	**4**
	Exp. > 10 years	Mean	2	2.5	3.25	4.25	3
		Rank	**1**	**2**	**4**	**5**	**3**

From the Table 8 above, it can be seen that all the groups of respondents have ranked limited knowledge as the most important factor, so there is need to increase the knowledge and awareness among the design professionals.

Factors contributing to success of SbD: There are several factors (listed in the Table 9 below) that contribute to the success of SbD. These factors were ranked based on Kendall's coefficient of concordance method to study if the ranking was done consistently or not.

Table 9: Matrix of Factors That Contribute to Success of SbD

k = 4	Factors contributing to success of SbD								
Respondents	Legislative force	Tools and guidelines	Support from industry	Engaging experts	Designer's mindset	Client's priority	Inclusion of safety provisions in the BoQ	Procurement guidelines	N = 8
Clients	1	4	7	6	3	8	5	2	
Contractors	4	3	1	2	6	5	7	8	
Er. in abroad	1	2	5	5	3	4	6	7	
Other Professionals	1	2	3	4	5	7	6	8	
Sum of Ranks (R_j)	7	11	16	17	17	24	24	25	Σ Rj = 141
$(R_j - \bar{R}j)^2$	172.73	83.59	17.16	9.88	9.88	14.88	14.88	23.59	s = 346.59

The value of W calculated is 0.44. Here the value of N is greater than 7, so $\chi 2$ value was calculated for determining the significance of W.

$\chi 2$ = k x (N-1) x W with (N-1) degrees of freedom i.e., 8-1 = 7

$\chi 2$ = 4 x (8-1) x 0.44 = 12.32

From the Chi-square Table, for d.f. = 7 value of $\chi 2$ is 14.07 which is greater than calculated value of 12.32. So, the null hypothesis is accepted and it was concluded that the different groups of respondents were applying different standard in ranking the N factors i.e., there was not significant agreement in ranking by different groups of respondents at 5% level in the given case. The lowest value observed amongst Rj is 7 for Legislative force and as such Legislative force can be determined as the most important factor of all followed by Tools and guidelines, Support from industry, Engaging experts, Designer's mindset, Inclusion of safety provisions in the BoQ, Client's priority and Procurement guidelines the least important factor based on values of sum of ranks (Rj). Thus, it can be concluded that SbD should be made mandatory by legislation and sufficient tools, guidelines, manuals and online resources should be published and made available to the design professionals for successful implementation of SbD.

The ranking of factors by different groups of respondents are given in the Table 10 below.

Table 10: Ranking of factors that contribute to success of SbD

Respondents	Factors	Legislative force	Tools and guidelines	Support from industry	Engaging experts	Designer's mindset	Clients's priority	Inclusion of safety provisions in the BoQ	Procurement guidelines
Clients	Mean	2.67	4.00	6.00	5.00	3.67	7.00	4.33	3.33
	Rank	**1**	**4**	**7**	**6**	**3**	**8**	**5**	**2**
Contractors	Mean	4.5	3.5	2.75	3.25	5	4.75	5.75	6.5
	Rank	**4**	**3**	**1**	**2**	**6**	**5**	**7**	**8**
Er. in abroad	Mean	2.17	3.83	5	5	4	4.33	5.17	6.5
	Rank	**1**	**2**	**5**	**5**	**3**	**4**	**6**	**7**
Other Professionals	Mean	2.32	3.09	4.15	4.43	4.60	5.74	5.43	6.23
	Rank	**1**	**2**	**3**	**4**	**5**	**7**	**6**	**8**

Respondents		Factors	Legislative force	Tools and guidelines	Support from industry	Engaging experts	Designer's mindset	Clients's priority	Inclusion of safety provisions in the BoQ	Procurement guidelines
Other Professionals	Exp. <= 5 years	Mean	2.45	3.55	4.55	4.1	4.5	5.9	5.45	5.55
		Rank	**1**	**2**	**5**	**3**	**4**	**8**	**6**	**7**
	Exp. 6 to 10 years	Mean	1.76	2.83	3.9	4.66	4.79	5.69	5.72	6.66
		Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Exp. > 10 years	Mean	5.75	2.75	4	4.5	3.75	5.25	3.25	6.75
		Rank	**7**	**1**	**4**	**5**	**3**	**6**	**2**	**8**

From the Table 10 above, it can be seen that apart from Contractors and Other Professionals with experience more than 10 years, the respondents from all the groups have ranked legislative force as the most important factor.

7.6 Knowledge and Awareness about use of SbD in different Project Activities

SbD relates to design related to safe construction, safe use, safe inspection, safe repair and maintenance and safe demolition. However only safe construction was selected by majority of 98.48% respondents which shows that there was a misconception regarding the SbD that it could be used only for the safety during construction period. It was also found that a certain group of respondents (59.09%) thinks that SbD deals with safety issues during safe use as well as safe repair and maintenance. From the figure below it can be seen that those group mostly includes respondents from Engineers in abroad and Other Professionals. The responses of different groups in isolation are shown in the Figure 2:

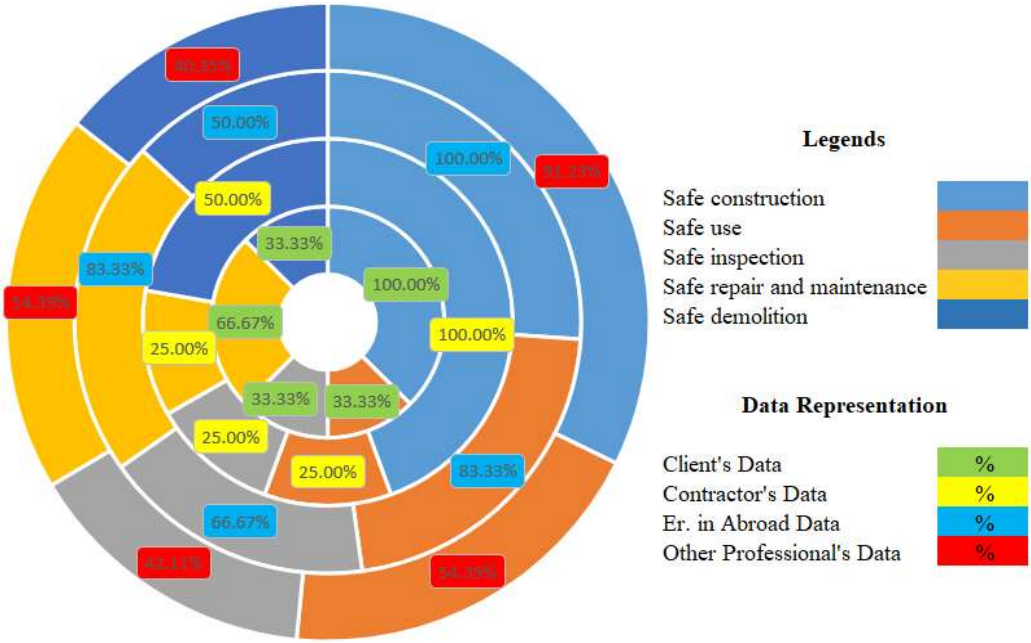

Fig. 2: Chart showing responses of various groups

7.7 Benefits and Problems of SbD

The responses of different groups in isolation are tabulated as below:

Table 11: Perception of Respondents about Benefits & Problems of SbD

Respondents	Clients		Contractors		Er. In Abroad		Other Professionals	
Description	N	%	N	%	N	%	N	%
Benefits of SbD								
Easier and cheaper to minimize risks in early stage	2	66.67%	3	75.00%	5	83.33%	46	80.70%

Efficient and effective to manage risk in the design phase	2	66.67%	4	100.00%	6	100.00%	36	63.16%
Improves health, wellbeing and productivity of workers	2	66.67%	2	50.00%	3	50.00%	38	66.67%
Reduce the need of PPE	1	33.33%	1	25.00%	1	16.67%	7	12.28%
Innovation of new ideas	1	33.33%	2	50.00%	1	16.67%	16	28.07%
Problems of SbD								
Lack of design guides/examples of safe design	2	66.67%	2	50.00%	4	66.67%	41	71.93%
Contractors comes in late in the design process impeding the ability to clarify on construction procedures	1	33.33%	0	0.00%	2	33.33%	28	49.12%
Quality/creativity of design concepts is compromised	2	66.67%	2	50.00%	5	83.33%	23	40.35%
Interferences with the contractor's means and methods	1	33.33%	0	0.00%	2	33.33%	19	33.33%
Lack of organizational support	1	33.33%	1	25.00%	3	50.00%	17	29.82%
Cost consideration from the Clients and or company	1	33.33%	2	50.00%	3	50.00%	28	49.12%
No mechanism in place to check for consistency in safety by design	1	33.33%	2	50.00%	3	50.00%	30	52.63%

Let's discuss in totality irrespective of table 11 where individual assessment was shown, around 84.85% of respondents considers that one of benefits of SbD is to minimize risks in early stage easily and cheaply. Also 72.73% of respondents think that managing risks in design phase efficiently and effectively is another benefit of the SbD whereas 68.18% of respondents think improving health, wellbeing and productivity of workers to be the benefits of SbD. Innovation of new ideas and reduced need of PPE were considered as benefits by 30.30% and 15.15% respectively.

74.24% of respondents thinks that lack of design guides are the major problems of SbD, alongside no mechanism to check for consistency in SbD and cost consideration from the Clients and or company being selected by 54.55% and 51.52% respectively. Also compromise in quality/creativity of design and no early contractor involvement was almost equally considered as problems of SbD by 48.48% and 46.97% respectively. The other two problems (inference with the contractor's means & methods and lack of organizational support) were selected by 33.33% of respondents each. Thus, it can be concluded that lack of design guides, manuals and online resources which could be used to enhance the knowledge of design professionals are the major problems for implementing the SbD. This shows that almost half of the respondents are not aware of the problems about SbD.

7.8 Duties of Designer

There are several duties of designers (listed in the Table 12 below) that they must do to manage the health and safety in construction phase. The responses of different groups in isolation are tabulated as below:

Table 12: Duties of Designer

Respondents	Clients		Contractors		Er. In Abroad		Other Professionals	
Description	N	%	N	%	N	%	N	%
Designer must do								
Make sure that they are competent	1	33.33%	1	25.00%	4	66.67%	21	36.84%
Prepare method statements for the	0	0.00%	3	75.00%	6	100.00%	32	56.14%

construction of their designs								
Prepare designs which avoid foreseeable risk during construction and thereafter	3	100.00%	3	75.00%	6	100.00%	39	68.42%
Provide adequate information about the design, and remaining risks	1	33.33%	3	75.00%	5	83.33%	26	45.61%
Co-operate with the Principal Designer & with other designers	1	33.33%	2	50.00%	5	83.33%	27	47.37%
Prepare the health and safety File	1	33.33%	2	50.00%	5	83.33%	26	45.61%
Co-ordinate their work with that of others in order to improve the way in which risks are managed and controlled	1	33.33%	3	75.00%	4	66.67%	26	45.61%

Again, considering together as different of table 12, 77.27% of respondents have selected preparing design that avoid the foreseeable risks during construction and thereafter as major duties of designer. 62.12% have considered preparing method statement for construction of design and 51.52% have selected preparing health and safety file as the duties of designer. However, both of them are not the duties of designer, significant number of respondents have opted for them. This clearly shows that the respondents lack the knowledge and awareness about the SbD. Preparing method statement are the duties of contractors whereas preparing health and safety files are the duties of safety officer. The remaining duties mentioned in the Table 12 above were selected by nearly half of the respondents. This shows that nearly half of respondents are not aware of duties of designer.

8. CONCLUSION AND RECOMMENDATION :

Safety by Design is an intervention that is gaining interest in the construction industry in European countries, USA, Australia and others, but still it has not become the part of standard design practice. In case of Nepal, it was found that the design professionals have heard of it but they do not have adequate knowledge about it.

8.1 Conclusion:

Most of the design professionals have heard of SbD from 2011 to 2020 during the college as a part of curriculum, but their understanding to SbD was found to be satisfactory to good. Understanding of the Clients was found to be satisfactory whereas that of Contractors was found to be good. Also understanding of Engineers in abroad was good. Similarly understanding of other design professionals with experience more than 10 years was found to be good whereas that of experience 6 to 10 years was satisfactory. Almost all of the design professionals from Clients, Contractors, Engineers in abroad and other design professionals think that implementation of SbD is very important however most of them haven't received training related to SbD.

Most of design professionals think that designers play important role in improving the safety status of the site as SbD is effective to improve the injuries and fatalities rate and they agree that SbD should be included in their professional duty, however the study also showed that they rarely get to address the worker's health and safety during the design phase. Most of the design professionals think that early contractor involvement is essential for SbD, as Contractors are the ones who faces most of the hazards during construction phase and they know the best way to deal with them. However, the contract management practices in Nepal merely follow the concept of early contractor involvement. Most of the

design professionals agreed that there are not sufficient guidelines, manuals, online resources or other materials that facilitate in using the SbD approach.

Almost all the design professionals agreed that Training Courses and handbook with pictorial representation are the best way that helps professionals better understand about the SbD and use it in construction industry. Also, online forum for design engineers could be effective in helping the design professionals better understand about the SbD. Limited knowledge regarding SbD was considered as the most important factor that restricted the use of SbD in the construction industry. Also, no regulatory provisions and designer's limited experience were the ones to restrict the use of SbD. Regarding the factors contributing to the success of SbD, design professionals agreed that legislative force is the most important factor followed by tools and guidelines related to SbD. Apart from them engaging the SbD experts and support from industry are equally important for success of SbD. Thus, it can be concluded that despite most of them have heard about SbD, due to their limited knowledge SbD approach has not been implemented in the site.

Research shall be conducted to access the status and practice of Safety by Design along with designer's motivation to implement the concept of SbD can be studied in the future studies. Another topic for further study could be the Job Safety Analysis of the activities listed in the discussion section that are required for construction of transmission line project.

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