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A Delphi study on building services engineers' core competence and statutory role in Hong Kong

Abstract

Purpose – The study aimed to narrow the diverse views of the industry stakeholders on two controversial issues, namely the scope of core competence of building services engineers (BSEs) and the statutory role that they should play, which were encountered in an extensive research study on the building services profession of Hong Kong.

Design/methodology/approach – An expert panel was formed and the Delphi method was applied to resolve the controversies. In the Delphi process, every panel member was provided with complete opinions expressed by all other panel members in each round of the deliberation.

Findings – Sufficient support was found for the proposition that professional BSEs should be competent in handling air-conditioning, electrical, fire services, and plumbing & drainage works, and that the government authorities should mandate the design and compliance certification of electrical and fire services installations by BSEs.

Research limitations/implications – Although the Delphi method has not been hitherto applied to resolve the controversies addressed in the study, it was proven to be a very effective tool in seeking majority opinions from a group of experts. The same approach may be taken in similar studies in future.

Practical implications – The core competence identified should be made as a minimum requirement for practitioners who wish to practise as professional BSEs. The views and comments given by the expert panel members are informative references to public policy makers.

Originality/value – This was the first ever study conducted in an attempt to identify the core competence and statutory role of BSEs in Hong Kong.

Keywords – Building services engineering; competence; Delphi method; Hong Kong; statutory role

Paper type – Research paper

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1. Background

Building services (BS), embracing primarily electrical, air-conditioning, plumbing & drainage, and fire protection installations, are essential to proper functioning of buildings. Satisfactory design, construction and operation and maintenance (O&M) of these installations entail not only the input of quality materials and equipments, but also the deployment of competent BS engineers. Since buildings are responsible for 40% or more of the total energy consumption of modern cities (EC, 2003; USGBC, 2009), which is consumed predominantly by BS systems, BS engineers shoulder a great responsibility in minimizing the adverse impacts due to consumption of resources, especially energy, in buildings (Levine et al., 2007).

Notwithstanding that BS installations appear in nearly all kinds of buildings, BS engineering was not a distinctive professional discipline until formation of the Chartered Institution of Building Services in the UK in 1976. Since then, professional engineers practising in this field in the UK and a few other places subject to strong British influence, including Hong Kong, began to style themselves as BS engineers, albeit, even now, not many laypersons know what BS is about (Yik et al., 2010). Elsewhere, engineers in this field may address themselves as MEP (mechanical, electrical and piping) engineers (e.g. in the US) or municipal engineers (e.g. in China) and, whilst there may be learnt societies that promote different sub-domains of BS engineering, e.g. the American Society of Heating, Refrigerating and Air-conditioning Engineers, there are no professional institutions that are dedicated to BS engineering.

In Hong Kong, the rapid economic growth in the past decades has led to the emergence of a huge stock of buildings, and a sizable BS profession. 2007 marked the 20th Anniversary of the BS Division (BSD) under the Hong Kong Institution of Engineers (HKIE) and, by then, BSD had already become the 3rd largest division in terms of membership size among all divisions under HKIE. As one of the anniversary celebration activities, a research study was initiated to explore means and measures for enhancing the future roles and functions of professional BS engineers in Hong Kong (Yik et al., 2008).

The research study, which was jointly undertaken by BSD of HKIE and the Hong Kong Polytechnic University over a period of more than two years, included reviews of the evolvement of the BS profession, the past and current roles and functions of BS engineers and regulatory controls over BS works in Hong Kong, as well as a comparison with the BS profession and practices in the UK, Singapore and China (with inputs from a research team in each country), and a few other regimes (by questionnaire survey). Through a series of interview and questionnaire surveys, views and opinions had been collected from not only BS engineers playing the roles of designers, equipment suppliers, installers and O&M managers, but also other building professionals (architects, structural engineers, surveyors, etc.), private sector developers, government departments that set policies, enforce regulatory controls and act as public project clients, as well as building tenants and the general public who are end-users of BS.

Findings of the extensive literature review, stakeholder interviews and questionnaire surveys conducted by the local team and the studies done by the overseas research teams provided much insight into the key issues that need to be addressed to ensure healthy development of the BS profession of Hong Kong and the means and measures that should be taken to enable professional BS engineers to make increasingly greater contributions to society (HKIE and

PolyU, 2010). For example, wider adoption of proper commissioning management (CIBSE, 2003; ASHRAE, 2005) was recommended for addressing the problems given rise by segregation of responsibilities among BS engineers responsible for design, installation, testing and commissioning (T&C) and O&M of BS systems at different stages of the life cycle of a building. Means for BS engineers to acquire the required knowledge and skills for enhancing sustainability of building and BS designs and quality of BS T&C and O&M works were found highly desirable.

To cope with the increasingly stringent user and regulatory requirements on indoor environmental quality and energy performance of buildings, and the needs for advanced technologies to meet these requirements, the proposition was made that BS engineers should become both a generalist, who is able to act as an agent for all aspects of BS while serving as a member of an integrated professional building design team, and a specialist in one or more specialized aspects of BS engineering. This proposition will have profound implications to the educational programmes for nurturing BS engineers and the criteria for admission of members for professional institutions in the field.

Nevertheless, before the research study could be concluded, the following two key issues remained controversial.

Diversity in scope of competence among BS engineers

BS is a relatively young engineering discipline evolved mainly from electrical and mechanical engineering (EE & ME). Education programmes dedicated to nurturing BS engineers have a much shorter history than EE & ME programmes (Chan and Burnett, 2004). In Hong Kong, the first higher education programme in BS engineering became available only in the late 80's (Au Yeung et al., 1993). Therefore, many practising BS engineers were educated in EE or ME. Even now, many EE & ME graduates choose to work in the BS field.

Besides educational background, division of work for raising productivity (e.g. in consulting firms) and multilayer subcontracting of BS works (Yik and Lai, 2008) are leading BS engineers into specialising in just one or a few BS trades. There is, therefore, diversity in the scope of competence among professional BS engineers which is incompatible with other construction professionals: except highly specialised works, a single architect or structural engineer is generally competent in handling all works within his/her scope.

The diversity in scope of competence, however, can lower BS engineers' work efficiency, such as delays in decision making and added complexity in coordination of different BS trades, which could offset the benefits of specialization and lead to undesirable omissions of critical works and project delays. BS engineers may even be regarded as insufficiently competent for not being able to handle some works which are within the domain of BS. They would also have greater difficulty in playing well their role in an integrated building professional team charged with the duty to turn out holistic solutions for sustainable building developments. However, given the wide range of BS trades that may be found in modern buildings, it is not possible for a professional BS engineer to be competent in all of them.

The survey of BS practitioners conducted in the study (HKIE and PolyU, 2010) unveiled that among the 196 respondents, they were, on average, competent in 2.9 BS trades. Among those who were competent in 3 BS trades, most of them were competent in heating, ventilating and air-conditioning (HVAC), electrical and fire services. However, the BS practitioners were, on

average, responsible for 4.5 BS trades. The most common combination of BS trades that they were responsible for includes HVAC, electrical, fire services and plumbing & drainage. These findings indicate that there exists a competence gap.

When asked about whether they consider competence in just one BS trade sufficient for one to become a professional BS engineer, i.e. for membership with a professional institution, 37% of them thought this would suffice but 63% thought otherwise. Among the latter group, the number of BS trades that they think a professional BS engineer should be competent in handling varied from 2 to 6, with 4 being the mode. The four BS trades that they regarded as the core competence of a professional BS engineer include HVAC, electrical, fire services and plumbing & drainage. The number of respondents who held this view, however, accounts only for about 14% of the total number of respondents, due mainly to the diversity in the opinions expressed by different respondents.

Diversity in scope of competence among professionals in a professional discipline is not unique to the BS profession but is rather common among different professions, especially those that are multi-disciplinary in nature. For some professional disciplines which, like the BS profession, are relatively new, attempts have been made to define the core competence of professionals in their disciplines, e.g. information services (Lee et al., 1995) and facility management (Bell, 1994; Clark and Hinxman, 1999; IFMA, 2007).

The abovementioned proposition that a professional BS engineer should be capable of playing both the roles of a generalist and a specialist (in one or a few specialized areas) was actually modelled on the medical and law professions (HKIE and PolyU, 2010). However, unlike specialists in these professions who, having progressed from generalist training to specialist training, would practise predominantly in their own specialist areas, this market segregation for the generalists and the specialists would be impossible for the BS profession except for a few very specialized areas, such as lighting and acoustics. Since expertises in the full range of BS are required in the vast majority of building development projects, participation of specialists of different sub-domains of BS engineering whose works are coordinated by a generalist was considered to be the way forward. Nevertheless, what would constitute the minimum core competence of a professional BS engineer remained to be defined to provide guidance on future development of educational programmes and assessment of applicants for membership of professional institutions.

The role of professional engineers in regulatory controls over building services works

In Hong Kong, BS that impact life safety, such as fire services, electrical and gas works and lifts & escalators, are subject to regulatory control, each under a specific ordinance. Scattered across different ordinances, the regulatory controls that affect BS works are under the jurisdiction of different enforcing authorities and are mostly supplementary to the main purposes of the respective ordinances. For instance, the requirements on ventilation, plumbing & drainage and energy performance of building envelope design are under the Buildings Ordinance the major concerns of which are on structural safety and health of building occupants. A range of requirements under the Factories and Industrial Undertakings Ordinance, which deals mainly with occupational health and safety, are applicable to BS works, especially maintenance works (Lai and Yik, 2004).

Among the existing regulatory controls over BS works, emphasis is put on the party or persons responsible for carrying out the installation works, such as the contractors and/or

workers for fire services, electrical, ventilation, plumbing and lift & escalator works, with virtually no involvement of professional engineers in the regulatory control processes even if those systems are designed by them. The requirements for registration as a qualified person on the statutory works are typically below the level of a professional engineer. Although a professional engineer registration system exists in Hong Kong and BS is one of the disciplines embraced by this system, few regulations require works to be done by or under the supervision of a Registered Professional Engineer in the BS discipline (RPE(BSS)). The building envelope energy performance submission, which is typically prepared by a BS engineer, has to be made by an Authorized Person who is most often an architect. Similar applies to drainage works.

In the BS practitioner survey, many BS engineers expressed discontent with the present regulatory controls over BS works. Some of them opined that design of fire services, electrical, plumbing & drainage, ventilation and lift & escalator installations should be carried out by professional engineers, likewise certification of compliance of these installation works. However, as found in the stakeholder interview surveys carried out in the same study, the relevant authorities held different views (HKIE and PolyU, 2010). Some of them considered that the present regulatory control framework served well the purposes of the controls and they saw no pressing need for changes.

Resolving the controversies

Given the diversity in the responses of different survey respondents and the controversy over the above two issues, an expert panel was formed and the panel members were requested to deliberate on these issues, through a Delphi process. The intention was to narrow down the diverse views to a few, if not a unanimous view.

2. The Expert Panel deliberation process

The Delphi method

Created at RAND by a team including Helmer and Norman (Aligica and Herritt, 2009), Delphi study is a method for structuring a group communication problem which would help obtain a reliable consensus and yet eliminate the dominance of certain members with high status and pressure on members to conform to the group (Van Zolingen and Klaassen, 2003). The study was initially conducted by face-to-face discussion (Helmer, 1975), and was later developed to include email communications, telephone conversations, and personal interviews.

The key features of a Delphi process include: engagement of experts, anonymity of the experts, repeated rounds of polling for expert opinions, controlled feedback, statistical group response and stability in responses among the experts on a specific issue. As a research tool, the Delphi method has been widely used for various purposes (Okoli and Pawlowski, 2004), such as identification of key competences of design-build clients of construction projects (Xia and Chan, 2010), and prioritization of factors for developing property investment criteria (Pivo, 2008).

The design of the deliberation process was based on the 'decision' Delphi (Van Zolingen and Klaassen, 2003). It involved setting up a panel of experts and soliciting the opinions of the panel members on the issue in question in several rounds of questionnaire survey. Since the

main objective of applying the Delphi method in the present study was to narrow down diverse opinions of different parties, including those who have different vested interests (e.g. among the authorities, design consultants and contractors), in addition to providing them with statistical data on the choices of all panel members, much greater emphasis was put on the feedback process such that the views and opinions given by individual expert panel members in support of their choices could be precisely communicated to all other members such that they could debate thoroughly on the issues in question.

For effective conduction of the process and to ensure the aim of this exercise are well-understood by all participants (Delbecq et al., 1975), all questionnaires and related documents were sent to the expert panel members through emails, and the panel members were requested to send their questionnaire returns to the study team also through emails.

Composition of the expert panel

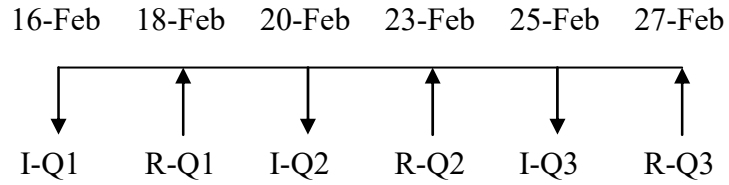
For obtaining a good cross-section of stakeholders and for ensuring high response rates to the multiple rounds of questionnaire survey, rather than the conventional approach of inviting individuals with extensive knowledge and experience in the local building and real estate industry (Adler and Ziglio, 1996), the key authorities, professional bodies and trade associations were identified and each was invited to nominate one representative to serve as a member of the expert panel. Given that there is no guideline on the minimum number of participants in a Delphi process (Brockhoff, 1975), the organisations selected were determined with due considerations given to the segments in the local construction industry that they represent and the maximum number of expert panel members that can be efficiently handled, both by the investigators in coordinating the communication process and by the panel members in digesting other members' views and opinions. The members of the expert panel assembled for the study included:

A. Authorities
    1. Buildings Department
    2. Electrical and Mechanical Services Department
    3. Fire Services Department
    4. Water Supplies Department
B. Public Project Clients
    5. Architectural Services Department
    6. Housing Department
C. Private Building Developers / Property Management Associations
    7. Hong Kong Association of Property Management Co Ltd
    8. Real Estate Developers Association of Hong Kong
D. Relevant Professional Institutions
    9. Building Services Operation and Maintenance Executives Society
    10. Chartered Institution of Building Services Engineers, Hong Kong Branch
    11. Hong Kong Institute of Architects
    12. Hong Kong Institute of Surveyors
    13. Hong Kong Institution of Engineers, Building Division
    14. Hong Kong Institution of Engineers, Building Services Division
    15. Hong Kong Institution of Engineers, Fire Division
    16. Hong Kong Institution of Engineers, Structural Division
    17. The Association of Consulting Engineers of Hong Kong
E. BS Contractors' Associations

18. Hong Kong Air Conditioning and Refrigeration Association Ltd
19. Hong Kong Electrical Contractors' Association
20. Hong Kong Plumbing & Sanitary Ware Trade Association
21. The Association of Registered Fire Service Installation Contractors of Hong Kong
22. The Lift and Escalator Contractors Association

The opinion survey process

Three rounds of opinion survey had been conducted according to the schedule shown in Figure 1. To begin with, a background document was sent to the expert panel members for informing them of the two issues that they were requested to deliberate upon, the importance of the issues to the future development of Hong Kong's BS profession and the relevant findings of the completed surveys (the contents of which are similar to the background information given in the preceding section). A questionnaire was also prepared for the members to provide their opinions on the issues in question and to given reasons for their answers.



Legend:
I-Q: Issuance of questionnaire and background document (for the 1st round) or summary of answers & reasons of the last round (for the other rounds)
R-Q: Return of questionnaire with answers & reasons by Expert Panel members

Figure 1 Schedule of expert panel member opinion survey

The questionnaire used in the first round opinion survey contained three questions. Part A of question 1 (Q.1.A) inquired into whether or not the panel members would agree that a professional BS engineer should be technically competent in handling more than one BS trade and if so, which trades would they consider as an essential element in the scope of competence of a professional BS engineer. Part B of the question (Q.1.B) asked if the panel members would agree that only candidates possessing such minimum competence should be admitted as corporate members of HKIE in the BS Discipline, which should be ensured through the professional assessment of applicants (Statement 1 under Q.1.B), and that HKIE should ensure the curricula of academic programmes for nurturing BS engineers would provide adequate coverage of the required range of BS trades before granting accreditation (Statement 2 under Q.1.B).

The second question was for finding out whether or not the expert panel members would agree that the design of electrical, fire services, ventilation, water supply & drainage and lift & escalator installations should be carried out by or under the supervision of a suitably qualified professional engineer who should also certify compliance of the design with the relevant regulatory controls. The third question was similar but pinpointed at installation works, including new and major retrofit works, and periodic inspection of existing installations for the same range of BS trades.

The background document and the questionnaire for the 1st round survey were sent by email to all the 22 expert panel members on 16 February 2009. As nominations had not been received from 3 organizations by that time, the document and questionnaire were sent to the respective organizations. Sixteen (16) questionnaire returns were received in the 1st round survey (two more later, after the 2nd round survey had commenced).

A nearly verbatim summary of the answers and reasons given by the expert panel members in their questionnaire returns in the 1st round survey but with the identities of individual members withheld was compiled and distributed to all panel members on 20 February 2009 to inform them of the answers and reasons given by other members. At the same time, a questionnaire, which contained the same questions as that used in the first round survey, was sent to the members. The members were invited to seriously consider other members' views before giving answers to the questions. Each of them was also requested to supplement his/her answers with reasons for persuading other members to take his/her views.

Nineteen (19) questionnaire returns were received in the 2nd round survey. Individual members' answers and reasons in the 2nd round were inserted into the summary compiled in the first round, with any changes in choices and further answers of individual members highlighted, which was issued to all expert panel members together with the questionnaire for the 3rd round survey on 25 February 2009. In this final round, the questionnaire contained 4 questions. The last two questions dealt separately with new and major retrofit works and periodic statutory inspections of the five trades of BS installations, which were covered by one single question (Q.3) in the 1st and 2nd rounds. This was found necessary as answers given by the members in the 2nd round tended to distinguish between these two kinds of works. Although the process could continue until consensus views were obtained, the process stopped at the end of the 3rd round survey.

Eighteen (18) questionnaire returns were received in the final round. A nearly verbatim summary of the answers and viewpoints expressed by all expert panel members in the 3 rounds of survey had been compiled to document the collected opinions, which had also been distributed to the panel members for their reference and record. Table 1 summarizes the number of questionnaire returns received and the methods adopted to deal with late/no returns from members in individual rounds of survey.

Table 1 No. of questionnaire returns received in the three rounds of survey

	No.	Remarks
1st round	18	With 2 late returns included
2nd round	19	The 1st round response of one member was included in compilation of the statistics for the 2nd round (assuming he did not change his answers), and thus the percentage of members choosing a particular answer was calculated based on a total of 20
3rd round	18	The responses of 2 members in the 1st round or 2nd round were included in compilation of the statistics for answers to Q.1 & Q.2 in the 3rd round and thus the percentage of members choosing a particular answer was calculated based on a total of 20; with the question changed, the same was not done for Q.3 & Q.4 for the 3rd round

3. Expert Panel members' opinions

General observations

Keeping track with the answers and opinions expressed by the expert panel members in the three rounds of survey unveiled that many members did seriously consider the viewpoints of other members while they reflected on their own standpoints and made their further opinions. As observed in the 2nd and the 3rd rounds of survey, a significant amount of cross-referencing to other members' opinions had been made by panel members in expressing their own opinions, and a considerable amount of changes had been made to the answers they had given in the earlier rounds. These are evidence that the Delphi process has served reasonably well its function.

Core competence of a professional building services engineer

On the question (Q.1.A) of whether a professional BS engineer should be competent in handling more than one trade of BS, consensus has been reached among the expert panel members since the second round of the survey (89% in the first round) that this should be taken as an objective of the BS profession and should be made a requirement for one to qualify as a professional BS engineer through membership with the Hong Kong Institution of Engineers (HKIE) in future. Figure 2 shows the expert panel members' answers regarding the trades of BS that a professional BS engineer should be competent in handling.

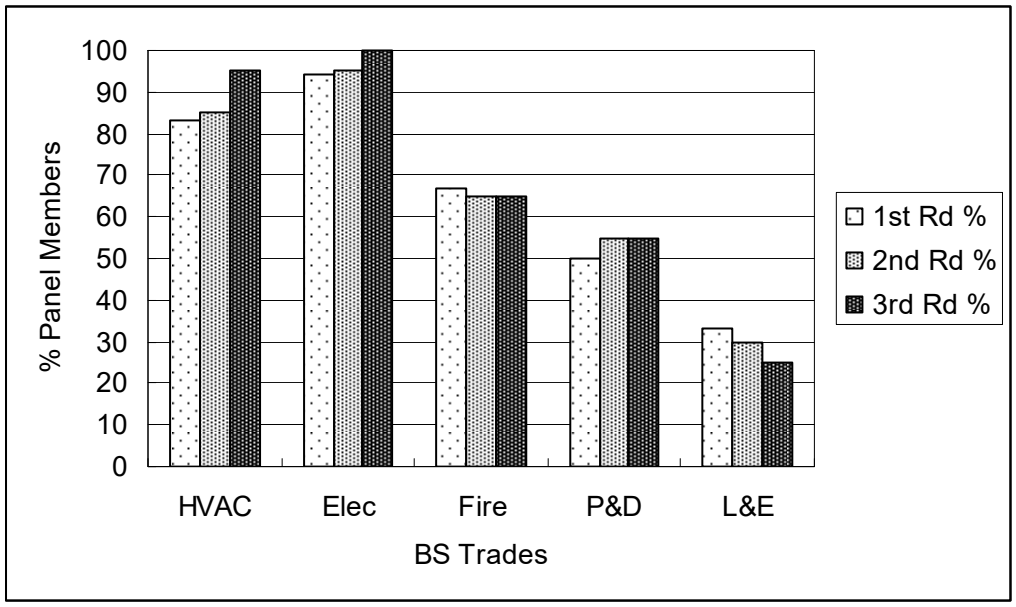


Figure 2 Opinions on the trades of BS that a professional BS engineer should be competent in handling

The key reasons given by the panel members in support of this opinion include:

1. This is one of the reasons for the emergence of the BS discipline, which is by nature a multi-faceted discipline; will help make the BS discipline distinctive from the traditional electrical and mechanical engineering disciplines from which the BS discipline has evolved; is the expectation of construction industry stakeholders and

the public; will benefit end-users of buildings; and will help promote the BS discipline in the society.

2. It will enable BS engineers to lead design effort to achieve integrated BS design; is a basic requirement for BS engineers to advance to senior positions; will enable BS engineers to individually and comprehensively deal with BS works in a manner on a par with other construction professionals; will enhance productivity, coordination of BS works and construction project management; will help ensure compliance of BS works with relevant regulatory controls; and will enable efficient and cost-effective solutions of intricate problems involving multiple trades of inter-related BS systems.

To help elucidate his perception about the scope and level of competence that a professional BS engineer should possess, one panel member paralleled a professional BS engineer with a family doctor, as follows:

> "*An analogy of professional BS engineer is the family doctor who is well recognized by the public as someone who can diagnose and give appropriate treatment to common diseases*."

Two other panel members emphasized that a professional BS engineer should have sufficient professional knowledge and experience in a range of BS systems by making the following very convincing statements:

> "*Otherwise, I doubt if a professional BS engineer will be regarded as a qualified professional engineer / competent person to undertake the design and installation of the engineering works under various safety ordinances*."

> "*It would be hard to explain to the public why an engineer with the designation of professional BS engineer is in fact not competent in or not trained for certain trades of common BS systems*."

Regarding the trades of BS that a professional BS engineer should be competent in handling, all the expert panel members concurred that electrical installation is essential and 95% of them also thought that HVAC installation is of equal importance (Figure 2). Fire services installation was regarded by 65% of the members as an aspect of competence required of professional BS engineers while plumbing & drainage (P&D) was likewise considered by 55% of them. However, only 25% of the panel members considered lift & escalator (L&E) to be a trade of BS that professional BS engineers should be competent in handling.

Those panel members who did not consider a professional BS engineer should also be competent in handling lift & escalator installations rightly pointed out that the involvement of BS engineers in lift & escalator designs is typically limited to traffic analysis and they are not familiar with the safety and operational control systems in such installations. Unquestionably, lift & escalator installations are specialist works that require substantial design input from the supplier / contractor as well as special skills in their installation and, therefore, have to be procured from specialist contractors through the use of performance specifications. However, works of a similar nature, though differ in extent, are not unfamiliar to BS engineers, such as BS systems and equipment that are proprietary products (e.g. chillers, standby generators, building automation systems, sewage treatment systems, etc.) (Yik et al., 2006).

Even though no explicit explanation had been given by those expert panel members who considered that a professional BS engineer should be competent in handling also lift & escalator installations, it is reasonable to assume that their opinion was based on the fact that BS engineers are often responsible for determining and specifying the required number, size and performance of lifts & escalators for buildings, for informing building design on the associated builder's works, and for management of the installation contracts. Given their involvement, it is fair to expect that BS engineers in design practices should be capable of carrying out the part of lift & escalator system design which is relevant to the transportation performance of the system and its integration with building design. However, the hardware design of lifts & escalators and their installation would be outside the scope of competence of BS engineers, and such work should be undertaken by specialists in the field, e.g. Registered Lift / Escalator Engineers. It follows that BS engineers should not be expected to be competent in checking and certifying the safety standard of lift & escalator installations.

In the light of the above discussions, lift & escalator installations may be regarded as similar to other BS installations like lighting, building automation, security, etc., about which BS engineers are expected to be knowledgeable enough to be able to handle the basic design, tendering and operational issues with, where required, supports from specialist, e.g. suppliers of the related system and equipment or specialist contracts for these installations.

In addition to their views on lift & escalator installations, the expert panel members held different views in respect of the combinations of BS trades that they perceived as the minimum scope of core competence required of a professional BS engineer, as shown in Table 2. However, those panel members who selected just one or two trades as their answers emphasized that competence in other trades, especially about the relevant safety and regulatory requirements, would remain essential but they did not explicitly mention what other trades should also be included. The major reason given for their answers was the difficulty for a BS engineer to acquire professional competence in all the five trades. Some members also considered that the needed technical competence would vary with the nature of work that individual BS engineers are engaged in and thus preferred to leave a degree of flexibility.

Table 2 Combination of BS trades considered to be core elements of the competence of a professional BS engineer

Combination of BS trades	No.	%
Elec	1	5
HVAC + Elec	5	25
HVAC + Elec + P&D	1	5
HVAC + Elec + Fire	3	15
HVAC + Elec + Fire + P&D	5	25
HVAC + Elec + Fire + P&D + L&E	5	25
Total No.	20	100

As shown in Table 2, 50% of the expert panel members considered that the competence required of a professional BS engineer should embrace HVAC, electrical, fire services and plumbing & drainage installations (with half of them considered that lift & escalator installations should also be included but this is considered inappropriate, as discussed above). Judging from the panel members' answers, more of them would have agreed to this viewpoint but they had reservation on the difficulty for a BS engineer to acquire professional

competence that covers fully this spectrum of BS trades. Admittedly, this is a hurdle which needs to be overcome by:

1. Clearly defining the required breath and depth of technical knowledge and skills pertaining to the required range of BS trades;

2. Ensuring academic programmes for nurturing BS engineers provide adequate coverage of the BS trades; and

3. Providing BS engineering graduates and junior BS engineers with adequate professional development training opportunities.

In this respect, the professional institutions in BS engineering, especially BSD of HKIE, would have a crucial role to play in helping the profession overcome the hurdle so as to heighten the standing of professional BS engineers in Hong Kong. As unveiled by their responses to the two statements in Q.1.B at the 3rd round of survey, all expert panel members agreed that HKIE should ensure the requirements for competence in multiple BS trades be met by the applicant in professional assessments for membership. Ninety percent (90%) of them also agreed that HKIE should ensure a BS engineering programme would be accredited provided only that its curriculum provides an adequate coverage of the required range of BS systems.

4. Regulatory controls over building services works

With particular reference to the role of professional engineers in regulatory controls over BS works, the expert panel members were requested to deliberate on design works and then on new and major retrofit works together with periodic inspection of existing installations by answering Q.2 & Q.3 in the questionnaires for the 1st and the 2nd round survey. However, after the 2nd round survey, it became apparent that some panel members distinguished new and major retrofit works from periodic inspection of existing installations in their answers to Q.3. Therefore, this question was replaced by two questions, Q.3 & Q.4, in the questionnaire for the 3rd round survey, such that panel members may indicate support on one but not support on the other without ambiguity.

Guiding principles

It can be seen from the opinions given in the questionnaire returns that many expert panel members provided explanations for their answers by outlining the principles that they used in judging whether or not they would support the proposition of requiring BS works to be undertaken by or under the supervision of a professional engineer; and of having a professional engineer to certify compliance of the BS works with relevant regulatory controls. The principles that the expert panel members used as guidance for their answers can be summarized as follows:

1. The fundamental principle that underpinned nearly all answers of the expert panel members is that a proposed regulatory control should only be introduced provided that it would be beneficial to the society, while the benefits should be greater than the costs for its implementation. Whereas better protection of public safety and health were regarded as the key beneficial factors, some panel members considered also

economic and environment benefits as factors for justification of imposing a regulatory control.

2. Many expert panel members paid attention to the social costs that would be incurred by enforcement of the proposed control. The relevant opinions given include:

   i) Over-regulation and complicated control processes should be avoided;

   ii) Large and complicated installations should be distinguished from small and simple installations in the consideration;

   iii) If self-regulation or market force is sufficiently effective, there is no need for regulatory control; and

   iv) Instead of relying on the concerned authority to undertake compliance checking, self-certification and third-party certification can help minimize the enforcement costs.

3. The level of technical expertise required for ensuring compliance with the relevant regulatory requirements was considered by some panel members as a factor that determines whether such statutory duty should be assumed by a professional engineer. The relevant principles they stated include:

   i) Whether or not professional judgement would need to be exercised; and

   ii) Whether the control is based on relatively straightforward, prescriptive criteria or more complex, performance-based criteria.

4. Some panel members held the view that clear line of authority and responsibility should be in place to avoid segregation or overlapping of liability, unfair allocation of liability and conflict of interests and thus considered that changing the regulatory framework would be worth considering if it can help rationalize the authority and responsibility of the involved parties.

5. Some panel members took the "*if it ain't broke, don't fix it*" attitude, which is a valid principle if the current arrangement is serving well the purpose of the control while making changes to it will certainly lead to increased costs. This reactive approach, however, is unable to drive improvements to current standards of safety, health, energy efficiency and environmental performance to cope with evolving needs of the society.

6. Some panel members stressed that the reactions of stakeholders to the proposed control should be taken into account, including the parties who would have to bear higher costs as well as those with vested interest but will be affected.

Role of professional engineer in regulatory controls over BS works

Figures 3 & 4 show respectively the expert panel members' views on whether professional engineers should be assigned a statutory duty to ensure design works, new and retrofit works,

and periodic statutory inspection of the five major trades of BS works are in compliance with the relevant regulatory controls.

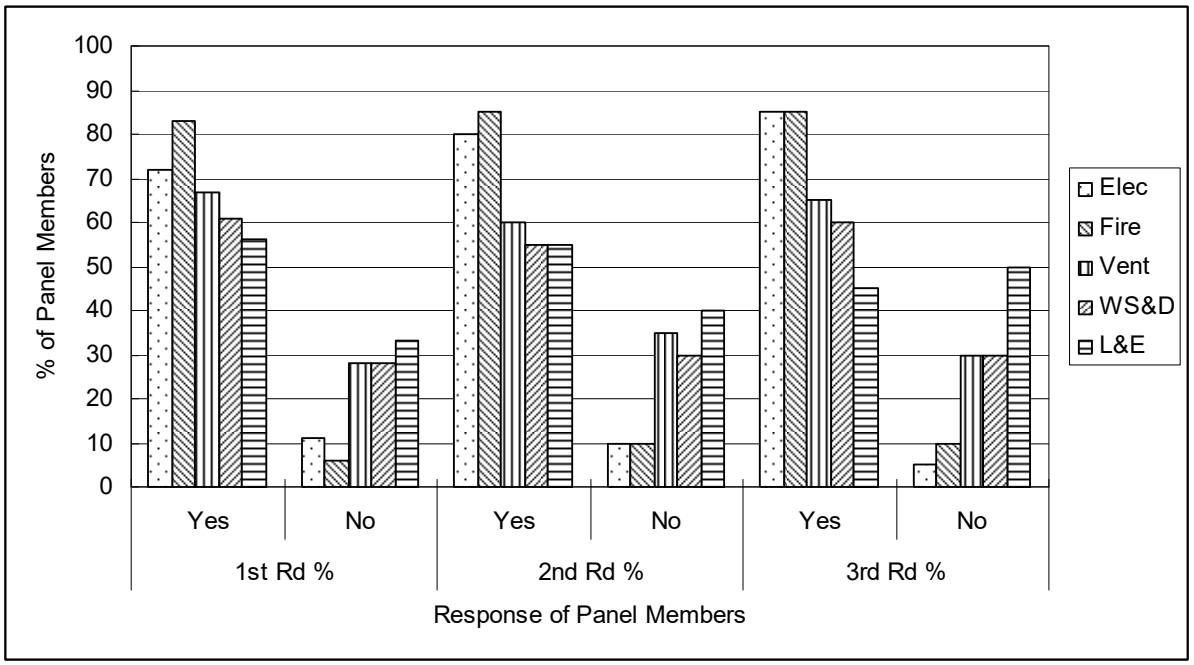


Figure 3 Views on role of professional engineers in ensuring compliance of design of the installation with regulatory controls

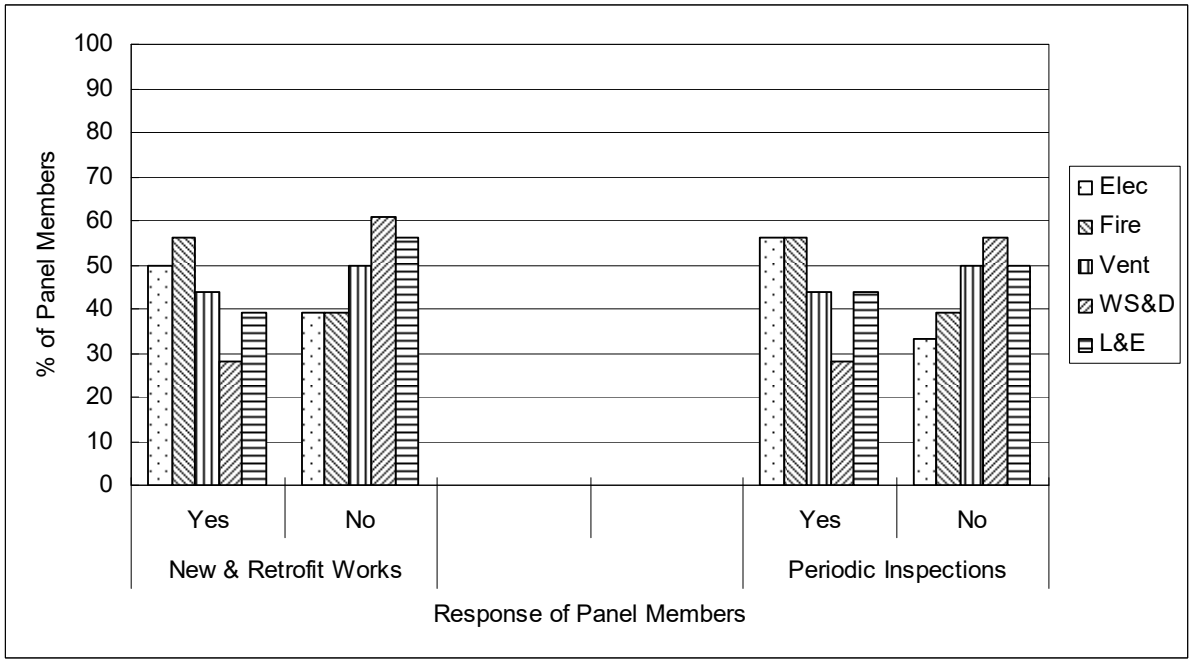


Figure 4 Views on role of professional engineers in ensuring compliance of: a) new and retrofit works and b) periodic statutory inspections of the installation with regulatory controls

As shown in Figure 3, after the three rounds of survey, the vast majority of the expert panel members (85%) agreed that design of electrical and fire services installations should be carried out by or under the supervision of a suitably qualified professional engineer (who may not necessarily be a professional BS engineer). This includes those who opined that the

requirement should be waived if the capacity of the installation falls below a threshold level, albeit they had different opinions on the threshold level to be used, or for certain kinds of works, e.g. modification works.

The support from the panel members to this proposition was weaker for ventilation (Vent) (65%) and water supply & drainage (WS&D) (60%) installations and even weaker for lift & escalator installations (45%); there were less panel members who agreed (9) that lift & escalator installations should be likewise treated than members who disagreed (10).

As to new & retrofit works and periodic statutory inspections, the expert panel members were having diverse views on whether such works should be carried out under the supervision of and be certified by a suitably qualified professional engineer (Figure 4). Although more panel members agreed to this proposition for electrical and fire services installations, they only accounted for less than 60% of the total number of members. For ventilation, water supply & drainage and lift & escalator installations, more panel members disagreed than those who agreed to this proposition.

Discussions on the views of the expert panel members

Under the present regulatory control framework, the consulting engineers who design electrical, fire services, ventilation, water supply & drainage and lift & escalator installations have very limited legal responsibility in respect of ensuring compliance of their designs with the relevant regulatory controls (although contractually and professionally, they do have such responsibility); the statutory duty of ensuring compliance of these installation works rests mainly with the Registered Contractors for the respective work trades.

For electrical works, only Registered Electrical Workers (REW) are permitted to carry out the works, which is mainly, though not solely, for ensuring the workers who carry out the works have adequate knowledge and have had sufficient training to carry out such works in a safe manner. Nonetheless, REW do have the statutory duty to certify compliance of installation and testing of completed electrical works. For plumbing works, the current regulatory control requires that such works must be carried out by Licensed Plumbers. For ensuring safety of lift & escalator installations, Registered Lift / Escalator Engineers are given the statutory duty to test and certify the compliance of lift & escalator installation works with the regulatory requirements, as well as certification of periodic inspection and testing. However, none of these 'competent' persons prescribed by the respective ordinances are required to possess technical competence up to the level of a professional engineer.

Since the Registered Contractor is assigned with the statutory duty to ensure all installation works carried out by him would comply with the relevant regulatory controls, performance of this statutory duty is invariably made a contractual obligation as well, which would imply a duty to rectify any parts of the design that fail to comply with the regulatory requirements at no extra cost to the client. This would not cause serious problems when the system is not complicated and regulatory controls are based on relatively straightforward, prescriptive requirements. However, problems could arise when the system is complicated and/or when performance based approach is used to demonstrate compliance, in which case it could go beyond the capability of, and is unfair to require, the Registered Contractor or the designated competent person (e.g. REW) to verify if the design could meet a safety standard that satisfies the regulatory requirements. Under the present control framework, however, the

Registered Contactor or the designated competent person would remain liable for any works that do not comply with the regulatory requirements.

For electrical and fire services installations, the vast majority of the expert panel members perceived that engaging a suitably qualified professional engineer to carry out / supervise the design work and to certify compliance of the designs of these installations with relevant regulatory controls would help enhance their safety standards. Although most panel members were referring, implicitly or explicitly, to the consulting engineer in answering this question, one of them categorically pointed out that the qualified professional engineer may not necessarily be the consulting engineer. However, if assurance of compliance of design were to be assumed by a professional engineer who did not carry out or supervise the design work, e.g. an engineer employed by a contractor, the potential problem with unfair distribution of contractual and legal liability cannot be resolved.

The disparity in legal responsibility between the designer and the installer was considered by some expert panel members to be unfair to the contractor and a cause of conflict of interest. For this reason, they supported requiring the design engineers to shoulder the responsibility of ensuring their designs comply with the relevant regulatory controls. In fact, the regulatory control system for fire services installations is moving toward self or third-party certification (Fire Services Department, 2007). Having a suitably qualified professional engineer to prepare and submit justifications of compliance with the relevant fire safety requirements using the performance based approach was also favoured by some members.

However, the panel members only indicated lukewarm support to the same proposition for ventilation and water supply & drainage installations because these installations were regarded as less critical to public safety and health; relatively simple in design; and straightforward in demonstration of compliance with the regulatory requirements. Requiring the designers of such installations to assume a statutory duty was thus considered not necessary and regarded by some as over-regulation.

Although ensuring life safety is extremely important for lift & escalator installations, the same proposition was rejected by many expert panel members. Their major reasons include that lifts & escalators are specialized works and other than those who are engaged in supply and installation of lifts & escalators, professional engineers are generally unfamiliar with the safety design and controls of lift & escalator installations. On the other hand, there are already registration systems for Registered Lift / Escalator Contractors and Engineers, which can address the need for ensuring public safety and were regarded as working well.

As shown by the statistics of the expert panel members' views (Figure 4), the proposition to introduce the requirement for supervision and certification of new installation and major retrofit works by a suitably qualified professional engineer was not supported by considerable numbers of panel members for the five major BS trades. Even for the electrical and fire services trades, many panel members (though less than 50%) opined that controls already exist on the respective Registered Contractors and are sufficient whilst adopting the proposed new requirement will increase social cost. For the same set of reasons, similar proposition for periodic statutory inspection was turned down by many expert panel members.

One panel member rejected the proposition by opining that:

> "*I do not think the professional engineer is more superior in industry regulation over other people's conduct. The direct framework of self-regulation is to register the specialist installation contractor and its responsible officers as is now. Depriving the contracting industry of the self-regulation regime will only drive the industry to lower quality and standard by market force. If outside regulation is deemed necessary (which is not the case), it should come from the relevant government works department, not professional engineers in the private sector*."

On the impacts on existing arrangements, including parties with vested interests, he further opined that:

> "*We need to exercise our political wisdom to take due consideration of the probable reactions from the labour unions, trade associations and the society at large.*"

These comments would need to be addressed in the light of the basic principles as summarized above. The relevant questions to be asked would be:

1. Is there an overriding need, from the perspective of the best interest of the society, to impose a regulatory requirement that installation works of contractors are to be supervised and certified by a professional engineer?

2. If the answer is yes to the above question, the associated question: should the professional engineer be the design engineer or one who works for the contractor and is responsibility for the installation works?

3. In relation to question 2, the question: can the responsibilities and liabilities pertaining to the design and installation works be clearly delimited in each of the two options?

The way in which building works are regulated is a good reference for answering the second and the third question above. Few would doubt that registered general building contractors would have sufficient expertise to check and ensure the building and structural works they carry out are in compliance with the relevant safety requirements but this has not relieved the Authorized Person and the Registered Structural Engineer of their respective statutory duties in ensuring the building works are safe and are in compliance with the Building Regulations.

For BS works, a BS contractor would be contractually responsible for carrying out the installation works in accordance with the requirements stipulated in the specification and shown in the drawings prepared by the design engineer who also has the contractual responsibility to make sure the contractor's works comply with the contract requirements. The design engineer may also issue from time to time variation orders for design changes and is responsible for certifying testing and commissioning and completion of the BS works. Given the involvement of the design engineer during the installation work, it would appear to be unfair to the BS contractor if he is held solely responsible for compliance of the BS installation with the relevant regulatory requirements. As discussed above, this disparity in legal responsibility between the designer and the installer has been taken by some expert panel members as a reason for supporting the proposition to have a professional engineer to carry out or supervise carrying out of design works and to certify compliance of the design.

Therefore, it may be argued that if there is sufficient justification for requiring installation works to be supervised, and compliance of the works certified, by a suitable qualified

professional engineer, the involvement of the design engineer in this process is logical. However, having supported the proposed control on the design of electrical and fire services installations, the two BS trades that have relatively high impacts on public safety, the support of the expert panel members to the same for other BS trades, and for installation and periodic inspection of BS works of all the five trades, was much weaker.

5. Conclusion

An expert panel comprising representatives of 22 government departments, professional institutions and trade associations, which are major stakeholder organizations of the building industry of Hong Kong, had been set up to deliberate on two controversial issues. The first is on the core competence of professional BS engineers and the other on the role of professional engineers in regulatory controls over BS works. Three rounds of opinion survey had been conducted. During this process, individual expert panel members' viewpoints were made known to all panel members such that they could consider other members' viewpoints before they made further opinions on the issues in question.

Based on the propositions that had the support of all or the majority of the expert panel members and an analysis on their viewpoints, there is sufficient support to the following propositions:

1. A professional BS engineer should be competent in handling multiple trades of BS, which should cover, as a minimum, HVAC, electrical (including lighting), fire services and plumbing & drainage installations. Additionally, he/she should be knowledgeable about lift & escalator and other common BS installations in buildings.

2. In future, demonstration of adequate competence in the minimum range of BS trades as stated in 1 above should be made a requirement for admission of applicants as corporate members of HKIE in the BS Discipline. The HKIE should clearly define the required breadth and depth of knowledge and skills for corporate membership in the BS Discipline and ensure academic programmes in BS engineering would be accredited provided that their curricula can provide adequate coverage of the required range of BS trades.

3. The authorities concerned should be urged to impose the regulatory requirement that the design of electrical and fire services installations shall be carried out by or under the supervision of a suitably qualified professional engineer who shall also certify the compliance of the design with the relevant regulatory controls.

However, the support given by the expert panel members to similar propositions as in item 3 above for the design of other BS trades, and for new and retrofit BS installation works and period inspection of existing BS installations, was much weaker. Nevertheless, realization of item 3 above would already be a very significant step forward in rationalization of the regulatory controls over BS works, which has the support of the vast majority of the expert panel members.

Although the Delphi method has not been hitherto applied to resolve the issues dealt with in the present study, it was proven to be a very effective tool in seeking majority opinions from a group of experts. Not only diverse views could be narrowed down through the deliberation

and view exchange process, sound, all-rounded and illuminating comments were obtained, which are highly informative references to public policy makers.

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