Report of the Investigation Committee
for the
CityU Sports Hall Incident
(The Redacted Version)

With a view to avoiding any prejudice (actual or perceived) to any
criminal and/or civil proceedings that may arise as a result of the
Incident, certain parts on pages 14, 15 and 16 of this Report
have been redacted.

6 June 2016
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Report of the Investigation Committee for the
CityU Sports Hall Incident

I. Executive Summary

The entire roof structure of the Chan Tai Ho Multi-purpose Hall (the Sports Hall) inside the Hu Fa Kuang Sports Centre (the Sports Centre) at City University of Hong Kong (CityU) collapsed on 20 May 2016.

Two staff members were injured by the intense blast of air caused by the roof collapsing, and a third individual was treated for shock. All three persons were hospitalised and discharged later the same day after treatment.

The roof greening of the Sports Hall was one of the items included in the “Design and Build: Roof Greening on Campus Buildings” project implemented by the Campus Development and Facilities Office (CDFO) in late 2015 as an Alterations, Additions, Repairs and Improvements (AA&I) project.

Campus safety is, and always will be, the top priority of the University. In order to allay public concerns following the Incident, the University took immediate action to remove vegetation from rooftops where steel structures similar to those at the Sports Hall were in place. CityU also started to review all roof greening works on campus and hired an Authorised Person (AP) and a Registered Structural Engineer (RSE) to conduct further safety inspections to other buildings with green roofing on campus.

On 23 May 2016, the President of the University, announced the formation of a nine-person Investigation Committee (IC) to find out as far as possible and practicable how and why this incident occurred so that the University can assure the Hong Kong community that the CityU campus continues to be a safe place to study and work. A report would be submitted to the President within two weeks.

During the course of the seven meetings, each lasting around three hours, the IC studied all the relevant documentation, sample materials and CCTV footage provided by CDFO, and met with those members of CDFO and Student Development Services who were either involved in the roof greening project and/or who had witnessed the Incident and possibly related events during the preceding period.

The IC (1) requested to meet with persons who had witnessed either the Incident and/or other critical events related to the Incident; and (2) invited a list of external professionals who were either involved in the design of the roof structure or the subsequent roof greening works of the Sports Hall. All external professionals declined the IC’s invitations.

Owing to the voluminous amount of documentation to be examined, the difficulties encountered in meeting with the Contractor, AP, and RSE of the roof greening
project, and the lack of on-site samples for accredited laboratory testing, the IC could only conclude its findings based on evidence drawn from documents examined and from meetings with staff members, on the balance of probabilities.

The IC observed that:

(1) the Contract document was prepared in alignment with normal industry practice and typical of a “Design and Build” contract, defining explicitly the responsibility of the Contractor in providing an AP (mandatory) and an RSE, and other professionals throughout the entire project to perform all required statutory checks and make submissions in compliance with the Building Ordinance;

(2) the procedures, from tendering to contract award, appeared to be in order, and no irregularities were identified;

(3) CDO had relied solely on the Contractor and its Project Team to perform their duties and fulfill their responsibilities under the Contract.

The IC concluded that:

(1) the design, construction and maintenance of the (original) structural roof are unlikely to be key contributing factors leading to the incident of the roof collapse;

(2) the overall design of the roof greening works of the Sports Hall, especially the loading assessment (coupled with apparent use of incorrect data/information), is likely the primary and core factor contributing to the collapse of the roof;

(3) the impact of rain, the soil materials used for the roof greening works, and the efficiency of the drainage system of the green roof system may also be important factors contributing to the collapse of the roof.

The IC has made a series of recommendations to the University on follow-up actions, with a view to further enhancing campus safety and preventing similar incidents in the future.
II. Background

(a) The CityU Sports Hall Incident

The CityU Sports Hall Incident (the Incident) refers to the collapse of the entire roof structure of the Chan Tai Ho Multi-purpose Hall (the Sports Hall) inside the Hu Fa Kuang Sports Centre (the Sports Centre) at City University of Hong Kong (CityU).

Shortly after 2pm on 20 May 2016, CityU’s Campus Development and Facilities Office (CDFO) received reports of serious flooding and of activated fire alarms in the Sports Hall. After they arrived at the scene, CDFO maintenance and security staff quickly suspected that the flooding, which was in the Sports Hall, was getting worse and that the loud sounds emanating from the roof of the Sports Hall appeared to be increasing in magnitude and frequency. In response, CDFO simultaneously 1) reported the incident to the Fire Services Department and 2) urgently evacuated all users and staff members who were inside the Sports Centre at the time. Two staff members who were organising the evacuation were injured by the intense blast of air caused by the roof collapsing, which happened at about 2.30pm, and a third individual employed in the catering service at CityU was treated for shock. All three persons were hospitalised and discharged later the same day after treatment.

(b) University Commitment to Campus Development and Sustainability

Campus planning is a crucial strategic area for CityU’s development as a higher education institution. In particular, sustainability initiatives such as the reduction of energy consumption, saving water and the greening of campus have been emphasised in order to improve campus facilities and provide inspirational social and learning spaces in support of the University’s strategic vision. The roof greening project of the Sports Hall was one of the items included in the “Design and Build: Roof Greening on Campus Buildings” project implemented by CDFO in late 2015 with funding support from the University Grants Committee as an Alterations, Additions, Repairs and Improvements (AA&I) project.

(c) Immediate Actions taken by the University

Campus safety is, and always will be, the top priority of the University. In order to allay public concerns following the Incident, the University took immediate action to remove vegetation from rooftops where steel structures similar to those at the Sports Hall were in place. CityU also started to review all roof greening works on campus and hired an Authorised Person (AP) and a Registered Structural Engineer (RSE) to conduct further safety inspections to related buildings on campus.

Professor Way Kuo, President of the University, formed a nine-person Investigation Committee (IC) to find out as far as possible and practicable how and why this incident occurred so that the University can assure the Hong Kong community that the CityU campus continues to be a safe place to study and work. IC membership comprised members of various CityU constituencies, including a
Council Member, a staff representative and two student representatives, plus two external professionals working in the field of structural engineering. They were:

Chairman
Professor Paul LAM Kwan-sing, Vice-President and Chief-of-Staff

Members
Professor CHUNG Kwok-fai, Associate Head, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University
Professor James LAU Chi-wang, Managing Director, James Lau & Associates Ltd and Fong On Construction Ltd
Mr Dominic PANG Yat-ting, CityU Council Member
Professor Horace IP Ho-shing, Vice-President (Student Affairs)
Professor Matthew LEE Kwok-on, Vice-President (Development and External Relations)
Mr MAK Hoi-wah, Assistant Professor, Department of Applied Social Sciences, Staff Representative
Ms WEI Jin-jin, President, City University of Hong Kong Postgraduate Association
Mr LEE Chak-hin, Acting President, City University of Hong Kong Students’ Union

Secretary
Ms Peggy WONG CHICK Bik-wah, Secretary to Management Board

The Terms of Reference of the IC were agreed by Members as below:

(1) To investigate the surrounding circumstances and identify the contributing factors leading to the incident of the roof collapse on 20 May 2016 (TOR 1);

(2) To examine and review if the procedures adopted for the green roof project of the Chan Tai Ho Multi-purpose Hall were in compliance with existing policies and regulations (TOR 2);

(3) To examine and identify if there were irregularities in awarding the contract and execution process, and in the subsequent internal management and implementation of the project (TOR 3);

(4) To make recommendations to the University on follow-up actions, based on the investigation findings, with a view to preventing similar incidents in the future (TOR 4); and

(5) To examine other matters that may be relevant to the foregoing (TOR 5).
III. Approach to the Investigation

In view of the intense public interest, the IC acknowledged the urgent need to complete its work within a relatively short period of time. It was agreed that every effort would be made to present a report to the President within two weeks from the Incident on 20 May 2016. In addition, the IC invited members of the University to provide information related to the maintenance and possible defects of the Sports Hall and nearby premises. A website was set up and linked from the CityU homepage as a means of collecting and disseminating information, thus enhancing communication with members of the University and the public. The Chairman also provided progress updates on the work of the IC to the media after six of the seven meetings.

On 23 May 2016, two members of the IC conducted a site inspection of the collapsed roof in the Sports Hall. During the course of the seven meetings, each lasting around three hours, the IC studied all the relevant documentation, sample materials and CCTV footage provided by CDFO, and met with those members of CDFO and Student Development Services who were either involved in the roof greening project and/or who had witnessed the Incident and possibly related events during the preceding period. By checking all pertinent facts, IC members aimed to understand the circumstances leading to the Incident.

The IC also took the following actions:

1. It requested to meet with students who had witnessed either the Incident and/or other critical events related to the Incident. However, these meetings could not be held due to the students’ prior engagements and the lack of time.

2. It invited a list of external professionals (Appendix I) who were either involved in the design of the structural (original) roof or the subsequent green roof of the Sports Hall. Regrettably, none of these individuals accepted the invitation, and as a result the IC was not able to obtain the views or evidence of those individuals.

3. It wished to have a closer examination of the site of the Incident on 31 May 2016 and collect samples of the deformed steel structure of the roof and the composites of the green roof and send them off for laboratory tests. Unfortunately, due to on-going temporary strengthening work at the site, access was not allowed by the Buildings Department.

Despite the above challenges and constraints, the IC made the following progress at each of its meetings with a view to completing its task with a report to be submitted to the President based on the information available and its appreciation of the facts:

1st Meeting, 23 May 2016 (Monday) at 9:00 am

- Agreed on a chronological summary of key events leading to the Incident for CDFO to provide the relevant documentation to the IC for examination and review (Appendix II)
2nd Meeting, 26 May 2016 (Thursday) at 2:30 pm

- Identified, on the basis of the information provided to, and reviewed by, the IC, a list of critical events for further enquiry and investigation (Appendix III)

3rd Meeting, 27 May 2016 (Friday) at 9:30 am

- Established a list of possible contributing factors to be considered further (Appendix IV)

4th Meeting, 30 May 2016 (Monday) at 2:30 pm

- Ensured, with the help of members on the IC with relevant professional expertise, a common and detailed understanding of the technical aspects of the design of the roof structure of the Sports Hall and the green roof
- Examined the effects of loading and drainage of the green roof design on the roof structure of the Sports Hall

5th Meeting, 31 May 2016 (Tuesday) at 2:30 pm

- Conducted a site visit by viewing the Sports Hall from the 17/F of Academic 3 and the 5/F of Academic 2
- Compared the engineering drawings and design calculations of the steel space frame of the roof structure of the Sports Hall between 1987 and 1989
- Established matching observations regarding the drainage, substrate (soil) and vegetation of the green roof from documentary analysis, the site visit at a distance, and the examination of samples provided by CDFO
- Agreed on the overall layout of the IC report

6th Meeting, 1 June 2016 (Wednesday) at 9:30 am

- Counter-checking the IC’s understanding and analysis of the green roof design with CDFO staff members involved in the roof greening project
- Counter-checking the IC’s assessment of the contributing factors leading to the Incident with staff members involved in the Incident and possibly related critical events during the preceding period

7th Meeting, 2 June 2016 (Thursday) at 2:30 pm

- Further counter-checking the IC’s assessment of the contributing factors with staff members of Student Development Services and CDFO
- Determination of the likely contributing factors leading to the Incident
IV. Findings

The IC notes that it is not a court of law and it was not formed to find out the definitive cause of the Incident nor who is legally responsible. Further, as access to the Sports Hall was not allowed, the findings in this report were based on visual inspections, and no formal forensic and laboratory tests on the structure or samples of the green roof from the Sports Hall could be obtained for the investigation. In this context and based on the strength of evidence drawn from documents and from meetings with staff members, the IC will conclude its findings on the balance of probabilities only.

TOR 1 – To investigate the surrounding circumstances and identify the contributing factors leading to the incident of the roof collapse on 20 May 2016

The documentary information provided by CDO and the information provided by staff members of CDO and of other departments who were either involved in the roof greening works, and/or had witnessed the occurrence of the Incident during the period of 1:45 pm to 2:45 pm on 20 May 2016, or critical events in the preceding period, largely tally and support the assessment of the IC on the possible contributing factors to the Incident. The following were agreed by the IC as important factors that should be taken into account in the understanding of the Incident but their likelihood of contributing to the occurrence of the Incident may vary.

(a) Design, Construction and Maintenance of the Structural (Original) Roof of the Sports Hall

The original roof of the Sports Hall is an inaccessible long-span structure made of steel measuring 42 metres by 36 metres in area. It was first designed in 1987 by Chung Wah Nan & Partners and Percy Thomas Partnership (Architects) and Mitchell, McFarlane, Brentnall & Partners (Consulting Engineers) with a set of loading calculations [Document L16i]. The design was subsequently modified in 1988 by Ove Arup & Partners Hong Kong Ltd with revised loading calculations at 0.75 kPa for Imposed Load and 4.75 kPa for Dead Load [Document L16k]. The new set of loading calculations was approved by the Buildings Department in February 1989. To the best of the IC’s knowledge, the construction of the original roof of the Sports Hall, which was completed in 1989, was based on the 1989 approved calculations.

The roof of the Sports Hall is a restricted area for maintenance personnel only and access to the roof structure requires a security procedure. No modification was made to the roof structure or other related areas of the Sports Hall between 1989 and late 2015 when the roof greening project commenced. These were confirmed by CDO. No damage to the roof structure has been reported and no complaints have been received regarding its safety until 10 May 2016 when some small cement chips were reported to have fallen from the roof during the examination period. It is noted that CDO conducts regular visual inspections for possible maintenance works on the roof structure, and CDO had planned to commission a comprehensive check on the building and the roof structure once
the Sports Hall had reached the statutory time frame for overall building maintenance under the Mandatory Building Inspection Scheme (MBIS).

From the set of photographs taken during the site inspection of the collapsed roof structure on 23 May 2016 [Exhibit A], it would appear from the visual inspection that:

1. The collapsed steel space frame suffered severe deformations in many structural members, in particular, bottom chords and diagonal members. In a number of connections, bolts were ripped off due to excessive deformations.

2. All guided supports of the steel space frame were severely damaged while all bearing supports had slid off the supporting wall structure.

3. A green protective paint system had been applied to the structural members and joints of the steel frame. No rust was visible in key structural members observed, such as top and bottom chords as well as diagonal members, during the inspection.

Based on the condition of the steel space frame after the collapse and the structural design of the roof when it was first built in 1989, the IC is of the view that, in general, the steel space frame appears to be structurally sound and well maintained. The IC concludes that the design, construction and maintenance of the (original) roof structure are unlikely to be key contributing factors leading to the Incident of the roof collapse.

(b) Design and Maintenance of the Green Roof System including the Drainage System

The Contract signed by CityU with Sinoway Construction Engineering Ltd (Sinoway or Contractor) for the “Design and Build: Roof Greening on Campus Buildings” project [Document B15c] had set out clearly CityU’s requirements for the design and maintenance of the green roof of the Sports Hall, including the related drainage system. The Contract, which had incorporated the tender documents as part of the Contract, covered a comprehensive range of the necessary components, including detailed drawings, the locations of the roofs to be retrofitted with the roof greening system, the materials to be used for the substrate (soil) and the growth media, etc. In particular, the design of the green roof was required to include drainage capable of shedding excess water in wet seasons and to take into consideration the loading and other implications of fully saturated soil and the associated vegetation.

In view of the light-weight nature of the steel space frame, the IC considers that the impact of the design (loading) calculations of the roof greening system on the steel space frame is of critical importance. The 1988 design calculations (approved in 1989) for the construction of the steel space frame at 0.75 kPa Imposed (Live) Load is the minimum generally required of any roof for servicing and maintenance purposes. However, the IC finds out that in the AP certificate of 20 October 2015 [Document E04] for the addition of Removable Tray Green Roof System at “Amenities Building Phase I (Amenities and Sports Block)”, where
the Sports Block is equivalent to the Sports Hall, a different set of data with 1.5 kPa as Imposed (Live) Load and 10.25 kPa as Dead Load was used. These figures did appear in a set of documents published in 1987, but this has been superseded by the subsequent design calculations approved in 1989. It is conceivable that the AP might have used an incorrect (outdated) set of loading data.

The AP certificate also certified, with reference to the catalogue and measurement report of saturated weight of the Removable Tray Green Roof System, the total weight of the system was 66.88 kg/m², i.e. 0.656 kPa, which was taken to be “within the design loading of imposed load and service load of such location”.

The IC strongly believes that there could have been an error in the design (loading) data/calculations of the roof greening system provided in the AP certificate submitted to CityU via the Contractor. Calculations based on 1.5 kPa as Imposed (Live) Load and 10.25 kPa as Dead Load for the roof structure of the Sports Hall would be wrong as the most up-to-date documentation approved in 1989 showed 0.75 kPa as Imposed Load and 4.75 kPa as Dead Load.

The IC considers it uncertain from the AP certificate whether the AP had consulted an RSE on the loading calculations of the roof greening system and of the roof structure of the Sports Hall. The 0.75 kPa loading is actually the minimum load of any roof. Furthermore, the IC is of the view that the weight of the roof greening system should in fact be considered as Dead Load and not Imposed (Live) Load. It appears to the IC that there has been an error in the AP’s reference data, calculation and/or judgement.

The IC concludes that the overall design of the roof greening works of the Sports Hall, especially the loading assessment (coupled with apparent use of incorrect data/information), is likely the primary and core factor contributing to the collapse of the roof.

The IC has also identified other possible contributing factors which will be covered in the following sections.

TOR 2 – To examine and review if the procedures adopted for the green roof project of Chan Tai Ho Multi-purpose Hall were in compliance with existing policies and regulations

(a) “Design and Build” Contract

There are two types of contract arrangements adopted by CDFO for building works on campus – the traditional model of appointing a consultant team (which does, among other jobs, the design) and a main contractor (who acts as the builder) separately for large-scale capital projects, and the “Design and Build” model by a single contractor for specialised works and/or smaller alterations and improvement projects. “Design and Build” contracts have been widely practised in recent years among government departments and UGC-funded institutions.
The roof greening work of the Sports Hall was an integral part of the roof greening project conducted by CDFO with funding support from the UGC as AA&I works. CDFO adopted the “Design and Build” contract arrangement for this project because it was considered to be not only a relatively small scale project but also because of the use of proprietary green roof products.

The IC understands that this arrangement was appropriate for this roof greening project because it has the advantage of minimising risks for CityU as the building owner, in particular when CDFO does not have the relevant in-house expertise, and it reduced the delivery schedule by overlapping the design phase and the construction phase of the project with a single point responsibility. It also carries the clearest contractual remedies for CityU as the client because the Contractor will assume single point responsibility (or turnkey responsibility) for all of the work on the project.

(b) The Contract Document [Document B15c]

The IC has reviewed the Contract signed by CityU with Sinoway. All the necessary details required of a typical “Design and Build” contract have been set out clearly in the Contract. The following paragraphs under the Employer's Requirements (ER) in the Contract are of relevance:

3.03 Description of the Works (page ER/31)

para.A – “Work under the instruction from the Director of CDFO as the Employer's Representative and the Project Manager, [the Contractor was required] to complete the “design and build” works under the Contract. The Works shall also include professional design presentations with professional design, presentation drawings and computer images to the satisfaction of Project Manager;”

para.B – “[The Contractor was required to] appoint Authorized Person (AP) (mandatory) and a multi-disciplinary consultancy team consisting of engineers such as Structural and Building Services, etc., for the planning, architectural, structural and building services including Lands, Planning and Building Submission under the Statutory Ordinances/Regulations and obtaining all other statutory approval for the Works under the contract including all qualified supervisory staff as required by the Buildings Authority or other statutory bodies for the successful completion of the Contract;”

para.C – “The Contractor shall obtain all relevant design data regarding the existing building, architecture, structure and building services etc., by carrying out his own surveys, desk studies, enquiries or through the Building Authority and relevant statutory organizations. The Project Manager was not obliged to provide any information to the Contractor whether they were readily available or not;”

5.01 Design Proposal and Document Submission (page ER/35)
1\textsuperscript{st} para - "...In the Design Proposal, the Tenderer must include a proposal of his project team including their proposed AP, Registered Structural Engineer, Building Services Engineer, Designers for Landscape and Automatic Irrigation System etc., with CVs of key personnel and their experience on similar projects. The Contractor should maintain the dedicated project team as proposed after Contract award until the completion of the Works. ..."

3\textsuperscript{rd} para - "After Contract award, the Contractor must submit their design of the Works with sufficient details to illustrate the compliance to the requirements as stipulated in the Contract. ... The Contractor shall be responsible for gathering and analyzing information from the users, understanding the users' needs and expectations, repeatedly making different proposals, and making repeated submissions and presentations to the users in sufficient details and formats as required by the users until the users fully understand and are satisfied with what has been designed and will be built."

From the above specifications in the Contract, the IC concluded that the Contract document was prepared in alignment with normal industry practice and typical of a "Design and Build" contract, defining explicitly the responsibility of the Contractor in providing the required professionals (especially the AP (mandatory) and the RSE) throughout the entire project, including all the required statutory checks and submissions in compliance with the Building Ordinance.

(c) Requirements of Submission of Plans to Buildings Department

The IC understood from the Director of CDOF that there was no submission for the roof greening system to the Buildings Department except for the water tank on the roof of Academic 1. It should be noted that the water tank provides water for irrigation of the vegetation, which was an integral part of the roof greening project covered by a single contract.

CDOF relied solely on the professional expertise of the Contractor, its Project Team, and the submitted AP certificate, which stated that after reviewing the design of Removable Tray Green Roof System, the installation of the System is not classified as the Building Works as defined in Section 2 of Cap 123 Buildings Ordinance. CDOF accepted the "professional advice".

CDOF also did not seek a second opinion in employing a third party professional to confirm the advice of the AP and/or to verify the data/calculations in the AP certificate because CDOF was convinced that both the Contractor and the AP, as required under the Contract, have sufficient knowledge, expertise and experience to ascertain the structural adequacy of the steel space frame in making such a judgement, as evidenced in the AP certificate.

The IC observed that CDOF had relied solely on the Contractor and its Project Team to perform their duties and fulfil their responsibilities under the Contract.
TOR 3 – To examine and identify if there were irregularities in awarding the contract and execution process, and in the subsequent internal management and implementation of the project

(a) Tender and Contract Award

The IC reviewed the tender documents and the eventual award of the Contract to Sinoway. Clarifications were sought from the Director of CDFO and his colleagues involved in the project on the tendering process. The sum of contract eventually awarded for the roof greening project was less than the tender prices listed in the tender assessment form [Document B13] due to budget constraints. The arrangement adopted by CDFO to reduce the project cost to meet the budget requirements was to reduce the number of areas for roof greening, but the roof greening work of the Sports Hall was included in the contract finally executed.

The IC considers that the procedures from tendering to contract award appear to be in order and no irregularities were identified.

(b) Implementation/Execution of Contract

(1) According to the Director of CDFO, who was stated as the Employer’s Representative in the Contract, the Facilities Manager (Estates) and Assistant Facilities Manager (Buildings) of CDFO were actually the named Project Manager and Project Manager’s Representative, respectively, in the Contract. The Director of CDFO confirmed that no staff members within CDFO possess a structural engineering background, including the two staff members directly involved in the roof greening project. It was also noted that there were no statutory requirements for the Project Manager to be an individual with the relevant expertise.

(2) In the Employer’s Requirements of the Contract, the Contractor was required to appoint an AP (mandatory) and RSE for the entire project. From the Organization Chart [Document C12] submitted by the Contractor, Mr Kenneth Chan Jor Kin was named as the AP with CV attached. An RSE was also named in the organization chart but no CV was attached. However, a different RSE is named, both in the Notice of appointment of AP and/or RSE (Form BA 4) and Application for approval of building plans (Form BA 5). In both forms, Mr Kenneth Chan signed as the AP and Mr Tsang Yin Sang as the RSE. Mr Kenneth Chan was also the person who issued the AP certificate dated 20 October 2015 to Sinoway for the addition of Removable Tray Green Roof System, which is the roof greening project undertaken by Sinoway for CityU.

To clarify the above issues, the IC wished to meet with Sinoway, Mr Chan and Mr Tsang to seek the necessary clarifications and facts. Invitation letters were sent to all three parties on 27 May 2016. Regrettably, all three persons declined the IC’s invitations. The IC followed up with a letter to Sinoway, hand-delivered on 30 May 2016, to seek advice on whether it had appointed an AP and a RSE for the roof greening project. Sinoway replied to our letter
on 3 June 2016 explaining that the Contract involves building works and non-building works. The letter states that, for the building works, Mr Chan Jor Kin Kenneth acted as the AP and Mr Tsang Yin Sang acted as the RSE. The letter further confirmed that KC Surveyors Limited (Mr Chan Jor Kin Kenneth’s company) was consulted on the works to be carried out, and advised and certified (as AP) that some of the works are non-building works. Sinoway’s letter also stated that “For those works classified as non-building works, the BO statutory requirements for AP and/or RSE have no application, and there is thus no AP and RSE role”. In Sinoway’s classification, “non-building works are the placing of green roof features on the roofs”. It would appear Sinoway by their letter only appointed an AP and a RSE in respect of what they classified as "building works”, which is inconsistent with the understanding given to the IC by CDOF staff that Sinoway is required to appoint an AP (mandatory) and a RSE for the entire project.

The IC considers that it has enough reasons to believe that Mr Chan was the appointed AP for the roof greening project according to the contract requirements; the organisation chart in the signed Contract; the AP certificate; Forms BA 4 and BA 5; as well as Sinoway’s letter dated 3 June 2016.

(3) Supervision and Monitoring by CDOF on Project Execution and Compliance

The IC understood from the Director of CDOF, the Project Manager, and the Project Manager’s Representative that

- Regular meetings and communications were held by CDOF staff with the staff of the Contractor throughout the project, including on-site discussions, despite the fact that monitoring and supervision by CityU as the client was not mandatory.

- The model with a weight of 66.6 kg/m² (i.e. a load of 0.66 kN/m²) was used as the roof greening system for the Sports Hall.

- Weight measurements of component materials of the roof greening system were demonstrated as 66.6 kg/m² by the Contractor before the commencement of the work, and CDOF witnessed the process. The roof greening system was weighed when the soils were saturated. After the works had been completed, CDOF staff inspected the height visually by comparison with the bordering curbs to assess if the materials exceeded the specified height. No weight measurements were taken.

- From time to time, CDOF checked the drainage of the roof of the Sports Hall during the roof greening project. There had been incidents of soil flushing out from the green roof system, and reports were made to the Contractor for rectification. The green roof system is still under the one-year Defects Liability Period by the Contractor.
CDFO received a report about falling debris in the Sports Hall on 10 May 2016 during the examination period. There was red rainstorm warning on the day. The debris comprised pieces of cement paste materials that fell mainly on the area near the right-hand corner facing the score board. [Exhibit B]. Witnesses also reported hearing two loud sounds coming from the roof. A follow-up visual inspection of the roof was conducted by CDFO staff on the next day, and a decision was made that a more detailed inspection by CDFO staff would be carried out when all scheduled events in the Sports Hall would have been completed, which would have been by 21 May 2016.

The IC also met with the staff who saw, and took photographs of, puddles of water on the green roof on 26 April [Exhibit C] and 17 May 2016 [Exhibit D] indicating that there might have been a drainage problem. It is noted that CDFO had reported the 26 April incident to Sinoway for rectification.

The IC also looked at the soil samples of the roof greening system taken from the Wei Hing Theatre (WHT) when the roof greening system was removed from WHT almost immediately after the Incident. WHT had the same roof greening system placed on a steel space frame structure similar to that of the Sports Hall. The green roof on WHT was built concurrently with the one on the Sports Hall. It was not possible to collect samples from the Sports Hall as it was sealed off by the Buildings Department. CDFO staff involved in landscaping work told the IC that the soil collected from WHT appeared, based on visual inspection, to be very different from the materials used for weight measurement demonstration in the presence of CDFO staff. The demonstration was conducted at around 4:00 pm during the Weekly Meeting held on 15 September 2015. According to measurements taken by CDFO staff, the weight of the roof greening materials collected from WHT was 91.33 kg for an area of 0.7 metres x 0.9 metres (i.e. over 140 kg/m²), which was much greater than 0.66 kPa recorded at the demonstration session before project commencement.

The IC also looked at weather reports published by the Hong Kong Observatory and did not notice any unusually long periods of heavy rainfall except that the total amount of rainfall on 10 May 2016, the day when students reported debris falling from the roof of the Sports Hall, was exceptionally high.

From the information collected above, in any case, the IC is of the view that in future, it would be prudent to not rely simply on the Contractor for maintenance and checks.
The IC considered the reports submitted by CityU staff members who witnessed puddles of water on the green roof of the Sports Hall and soiled water running off the edge of the green roof. The IC also assessed the impact of rain, the type of soil materials used for the roof greening system and the efficiency of the drainage system of both the green roof and the structural (original) roof. The IC is of the view that these are also important factors contributing to the collapse of the roof structure.

V. To make recommendations to the University on follow-up actions, based on the investigation findings, with a view to preventing similar incidents in the future (TOR 4)

(1) CityU should seek professional advice on commencement of legal proceedings against parties that appear to be responsible for the collapse of the roof,

(2) To achieve a standard beyond what is legally required, the organisational structure of CDFO should be thoroughly reviewed with a view to having at least one qualified person for each key discipline or area, e.g. a structural engineer, given the wide range and different nature of the buildings and AA&I projects conducted on campus on a regular basis. This will help to ensure that the project team has the necessary knowledge and expertise to oversee the project, scrutinise all works and respond to various legal requirements.

(3) The IC also recommends the following best practices for the consideration of CDFO:

- Maintaining a full set of the design and structural calculations/drawings approved by relevant government departments for all the buildings on campus, including subsequent approved changes to the structural plan, for the purpose of good record keeping for future reference;

- Verifying the data and advice provided by APs to the best of CDFO’s abilities, such as consulting independent and professional opinions from third-party experts if there is no relevant expertise within CDFO, if and when it is necessary. In particular, obtaining a second opinion from an independent RSE (or other qualified professional) for any works on buildings that may result in a permanent change in loading;

- Conducting regular structural inspections of buildings on campus as a best practice beyond various legal requirements; and

- Checking whenever possible with the original structural designer or design on the feasibility of new projects in the future.

(4) CityU should consider appropriate follow-up action, e.g. disciplinary action, against
(5) CityU should conduct a thorough assessment on the structural integrity of all the green-roof areas covered in the Contract to ensure safety.

VI. To examine other matters that may be relevant to the foregoing (TOR 5)

The IC commends the CityU staff who responded so promptly to the activation of the alarm system with all actions possible to check and assess the flooding situation in the Sports Hall, and made the right decision at the earliest possible instance to evacuate all users from the Sports Hall. The IC wishes to record its sincere appreciation for the bravery of these individuals, whom the IC has met with, and would like to wish them a speedy recovery from the shock and trauma that they may have suffered because of the Incident.

VII. Concluding Remarks

The IC appreciates that CityU has put a great deal of effort into greening campus as part of a sustainability initiative. However, roof greening currently lacks clear safety regulations/guidelines. The structure receiving the greening should be checked by a structural engineer and, in all cases, the design should be vetted by an AP and/or a RSE. The structural design and calculations for the roofs should be properly checked.

The collapse of the roof structure of the Sports Hall could have been caused by an error in the design/loading calculations/judgement of the roof greening system on the steel space frame of the Sports Hall. The set of data used by the AP could have been wrongly based on the design calculations of the structural (original) roof in 1987 which were subsequently superseded by the modified calculations approved in 1989. Furthermore, the weight of the roof greening system should in fact be considered as Dead Load and not Imposed (Live) Load. It was very fortunate that no lives were lost. What is important to note is that we all – CityU, the Hong Kong Government, legislators, the construction industry, landscapers and promoters of green culture in Hong Kong – need to learn from this Incident and take note that decisions concerning roof greening should be premised upon the priority of structural safety.

Acknowledgements

The IC would like to take this opportunity to thank all members of the University who have contributed valuable information related to the Incident online for the IC’s review, and all staff members who have taken time out of their busy schedule to meet with the IC in person.
Appendices –

I. List of external professionals invited to meet with the IC

II. Chronological summary of key events

III. List of critical events for detailed enquiry and investigation

IV. List of possible contributing factors to be considered in relation to the Incident

V. List of staff members interviewed by the IC

VI. List of documents provided by CDFO

VII. List of information reports received from members of the University and from the public

VIII. Technical comments by Professor James LAU Chi-wang on the CityU Sports Hall Incident

Exhibits A-D

Documents L16j; L16k; B15c; E04; B13; and C12