For Discussion on
28 September 2021

LEGISLATIVE COUNCIL
PANEL ON DEVELOPMENT

Update on Landslip Prevention and Mitigation Programme

PURPOSE

This paper briefs Members on the progress of Landslip Prevention and Mitigation Programmme (LPMitP) and the application of innovation and technology for the implementation of the LPMitP.

INTRODUCTION

2. In 2015, the Civil Engineering and Development Department (CEDD) submitted a discussion paper on LPMitP (Ref: CB(1)105/15-16(04)) to the Panel on Development. In the paper, CEDD reported that the Slope Safety Technical Review Board (SSTRB)[1] supported our slope safety system and risk-based priority ranking systems, and concluded that the LPMitP was in satisfactory progress and delivering the following annual pledged outputs in an effective manner:

(a) to upgrade 150 government man-made slopes;

(b) to conduct safety-screening studies for 100 private man-made slopes; and

(c) to implement risk mitigation works for 30 natural hillside catchments.

3. Further to the above report, the latest progress of the LPMitP and the related application of innovation and technology are presented in this paper.

[1] The Slope Safety Technical Review Board (SSTRB), which comprises three internationally renowned geotechnical experts, was established in 1995 to independently review the Government's work in slope safety management and advise on the technical aspects of the slope safety system.

PROGRESS OF LPMitP

4. The annual outputs of slope upgrading works for government man-made slopes, safety screening studies for private man-made slopes and risk mitigation works for natural hillside catchments from 2011 to 2020 under the implementation of LPMitP are shown in **Annex A**. The average annual expenditure incurred in the implementation of LPMitP was about $1,000 million.

5. From 2015 to 2020, we have achieved the pledged annual delivery targets. We expect that the average annual expenditure for the LPMitP in the coming years would need to be maintained at a similar level of $1,000 million in order to achieve the pledged targets continuously.

6. The Landslip Preventive Measures Programme (LPMP), which was completed in 2010, mainly dealt with high-risk man-made slopes[2]. Upon completion of the LPMP, the majority of the remaining landslide risk of man-made slopes comes from those with moderate risk[3] or affecting squatter dwellings[4]. In 2015, there were about 17,600 substandard man-made slopes with moderate risk and those affecting squatter dwellings, and 2,800 vulnerable natural hillside catchments[5] in Hong Kong. Some of the substandard man-made slopes and vulnerable natural hillside catchments were subsequently dealt with under the LPMitP in recent years.

7. Under the influence of climate change, more extreme and frequent rainfall events leading to landslide incidents will happen every year. Recent studies on landslides in association with extreme rainfall events and technical advances in the understanding and identification of natural terrain landslide hazards led to the identification of about 700 additional vulnerable natural hillside catchments. At present, there are still about 16,100 substandard man-made slopes with moderate risk or affecting squatter dwellings and about 3,300 vulnerable natural hillside catchments in Hong Kong.

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[2] Man-made slopes with high risk include old man-made slopes (i.e. formed before 1977) affecting residential buildings, hospitals, schools, etc.

[3] Man-made slopes with moderate risk refer to old man-made slopes affecting major infrastructures, heavily used roads and footpaths, public waiting areas, and those formed between 1977 and the late 1980 using old technology (i.e. typically by slope trimming to a less steep gradient and without structural elements).

[4] Squatter dwellings refer to those dwellings surveyed and registered by the Housing Department in their 1982 Squatter Control Survey. A squatter dwelling may contain one or more squatter structures.

[5] Vulnerable natural hillside catchments refer to those natural hillside catchments with known hazards and close to existing buildings and important transport corridors.

CHALLENGES ENCOUNTERED IN IMPLEMENTATION OF LPMitP

8. Looking ahead, the landslide risk in Hong Kong is increasing with time due to encroachment of continued development onto steep natural terrain, slope degradation, and the increasingly frequent extreme weather events arising from climate change. CEDD will adopt a more holistic approach to combat the landslide risk.

9. The risk-based priority ranking of the man-made slopes and natural hillside catchments need to be updated regularly in order to ensure that the most deserving candidates would be selected for action under the LPMitP. Occurrence of new landslides and technical advances in the understanding of landslide hazards call for the need to identify additional vulnerable natural hillside catchments and review their priority in a timely manner.

10. Many man-made slopes and natural hillside catchments selected for action under the LPMitP are close to existing buildings and important transport corridors. Apart from overcoming the congested site constraints, we have strived to devise measures to minimize nuisance to the nearby residents and road users, so as to mitigate environmental impact and traffic disruption during the implementation of LPMitP.

11. As debris flows can be very mobile, failures on some natural hillside catchments located at a considerable distance could still pose threats to affect facilities. These catchments could be located in sensitive areas such as country parks, Sites of Special Scientific Interest or Conservation Areas. In these cases, ecological impact assessments are required. If species of conservation importance are identified, relevant protection or mitigation measures are necessary. We may also need to suitably adjust the design of mitigation works for natural hillside catchments, where possible, to minimize the ecological impacts. In general, studies of catchments in sensitive areas require input from relevant experts and more time to go through the design and preparation processes before the works can be packaged into works contracts for implementation.

12. In addition, vulnerable natural hillside catchments are usually extensive and covered by thick vegetation. At times, it could be difficult to conduct detailed inspections and field studies to assess the landslide risks as well as to design the mitigation works to suit the actual ground condition.

13. In light of the foregoing challenges, we have taken advantage of the innovation and technology to assist us in delivering the works projects and

maintaining the pledged outputs.

APPLICATION OF INNOVATION AND TECHNOLOGY

14. CEDD is always committed to keeping pace with the latest technology. We continue with technical development work on slope safety by in-house research teams as well as in collaboration with other organizations and universities. For instance, pioneering development work was conducted to study the behavior of debris-resisting barriers[6] to mitigate landslide risk from vulnerable natural hillside catchments leading to the promulgation of new guidelines for the industry to optimize the design.

15. Our recent endeavours in applying innovation and technology to enhance the implementation of LPMitP include:-

(a) improving the identification of vulnerable natural hillside catchments;

(b) enhancing design workflow and cost-effectiveness;

(c) facilitating construction of works; and

(d) developing landslide detection system.

Improving the identification of vulnerable natural hillside catchments

16. In 2020, CEDD completed the second round of airborne Light Detection and Ranging (LiDAR)[7] survey for the entire territory. Capitalizing on the advances in the LiDAR technology, the digital terrain model generated from the new LiDAR dataset with higher density of data provides a high-resolution ground profile, from which details of more subtle features become discernible. This new LiDAR dataset would offer essential information for identifying relict natural terrain landslides and understanding landslide hazards.

17. The vulnerable natural hillside catchments are at present identified based on an inventory of natural terrain landslides compiled through time-consuming manual examination of historical aerial photographs by geologists with regular updates. CEDD is experimenting with the use of artificial

[6] Debris resisting barriers are landslide risk mitigation measures, usually made of concrete, to contain landslide debris, and thus minimize casualties due to debris impact on adjacent buildings and facilities.

[7] LiDAR is a remote sensing technology using the pulse from a laser to collect 3-dimensional measurements of the ground profile.

intelligence (AI) to automate the identification, delineation of landslide extent and classification of landslides based on aerial photographs. With the advances in remote sensing technology used in satellites, different scales of landslides could be identified using satellite images with high-resolution. CEDD also extends the above study on AI using satellite imagery. Utilizing deep learning technology specific to visual data and analyses of aerial photographs and satellite imagery, this automation aims to speed up the process of identification of vulnerable natural hillside catchments.

Enhancing design workflow and cost-effectiveness

18. CEDD invested considerable efforts in developing digital automated design workflow by using Building Information Modelling (BIM)[8] for optimizing the design, improving buildability and further enhancing cost-effectiveness and minimizing human errors. Data generated from laser scanning, airborne LiDAR, 3-dimensional ground models and information about underground facilities can be imported into BIM for hazard assessment. The use of BIM enables us to tackle complex topography, geological conditions and underground facilities in a more effective and efficient manner.

19. CEDD applies the latest photogrammetry technology for processing videos captured by mobile smartphones to generate 3-dimensional models. The photogrammetry technology can also be applied to videos taken by unmanned aerial vehicles (UAV) which can provide terrain information swiftly for hazard assessment and design of mitigation works.

20. CEDD has commenced a pilot study to examine the feasibility of using quadruped robots in carrying out inspections where the environment is potentially dangerous or difficult to access, including sensitive areas. Customization was carried out to enhance the robots' manoeuvrability and allow installation of additional equipment for data collection, including hand-held laser scanner, high resolution camera, etc. The collected data can facilitate the establishment of 3-dimensional ground model of the sites and the design of the mitigation works located in remote areas covered by thick vegetation or where use of UAV may not be suitable.

Facilitating construction of works

21. The upgrading works for man-made slopes sometimes involve

[8] BIM is a digital modelling system that has been widely used in construction industry in recent years to holistically manage various 3-dimensional digital building data throughout the whole life cycle by using digital simulation software.

excavation and backfilling by recompaction method[9], which is time-consuming and weather dependent. As most of the works are adjacent to existing buildings and major roads, they inevitably cause some disruption to the public. Collaborating with a local research organization, CEDD pioneers the application of a novel self-compacting backfilling material for slope upgrading works with a view to enhancing productivity and improving the quality of recompaction of the backfill.

Developing Landslide detection system

22. CEDD developed a landslide detection system (called Smart Barrier System) which was installed in debris-resisting barriers as pilot trials to enhance emergency response. With the use of Internet of Things (IoT) sensors, the Smart Barrier System allows all-weathered and 24-hour monitoring of the site conditions and provides an instant alert via a mobile application when landslide debris impacts the debris-resisting barriers, enabling timely arrangement of inspections and follow-up actions to enhance public safety.

23. In 2020, SSTRB remarked that CEDD continued to lead international practice on slope safety. CEDD will continue to strengthen the application of the state-of-art innovation and technology to collect slope and landslide data to enhance the efficiency of implementation of the slope works, landslip warning and emergency services, and continuously optimize our capability to prevent and mitigate landslip.

BACKGROUND

24. Under the LPMP which was completed in 2010, the overall landslide risk from man-made slopes was substantially reduced to less than 25% of that existed in 1977, reaching a reasonably low level that is commensurate with the international best practice in risk management.

25. After CEDD briefed the Panel on Development vide LegCo Brief (Ref: DEVB(CR)(W) 1 – 150/72) on "Post-2010 Landslip Prevention and Mitigation Programme" in late 2007, the LPMitP with an expanded scope covering also natural hillside catchments was launched in 2011 to dovetail with the completed LPMP.

26. In October 2009, the Panel on Development was then briefed vide LegCo Brief (ref: DEVB(CR)(W) 1 – 150/31) that the landslide risks posed to

[9] Recompaction is the traditional method for upgrading loose fill slopes in Hong Kong which requires time consuming compaction procedures and large amount of field tests to ensure compliance of the backfilled material with the specification requirements.

squatter dwellings would be dealt with by carrying out engineering works to squatter slopes, where non-development clearance of squatters by persuasion is not successful.

27. CEDD completed the review of LPMitP in 2015 (Ref: CB(1)105/15-16(04)). CEDD considered that the pledged annual delivery targets of LPMitP were appropriate in balancing landslide risk against disturbance to the general public, and recommended to continue with the implementation of LPMitP with the pledged annual outputs remaining unchanged.

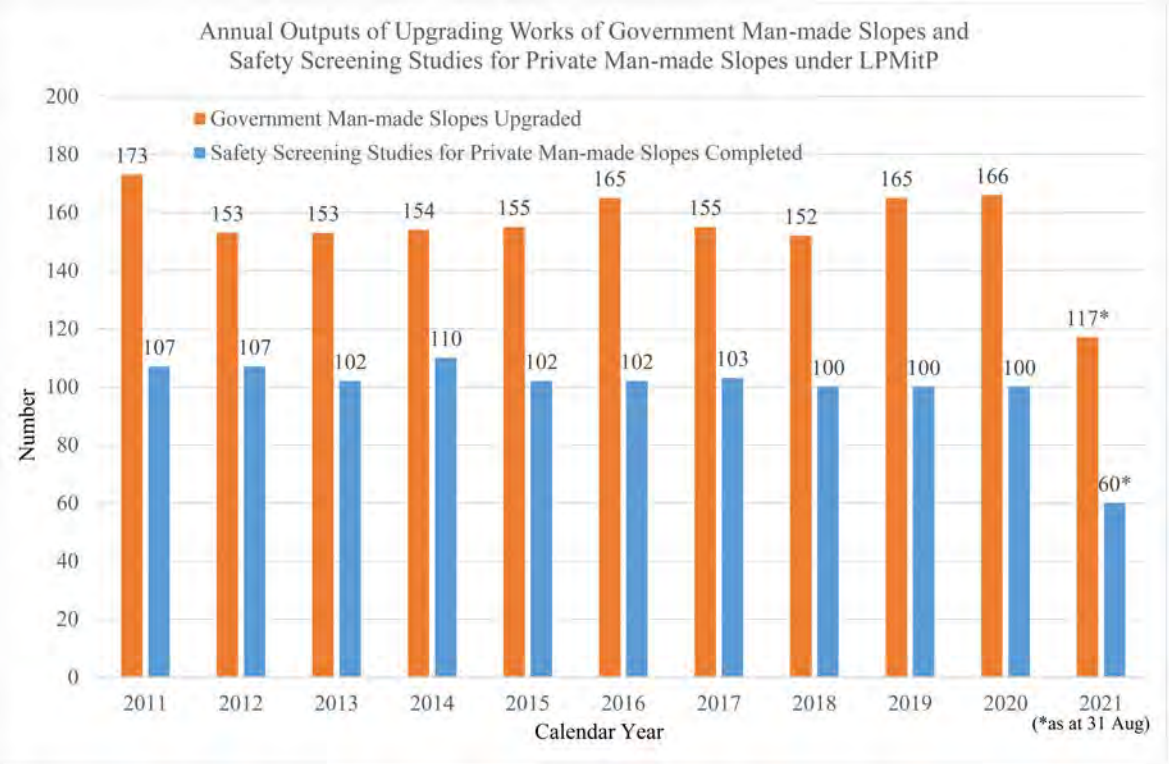
CONCLUSION

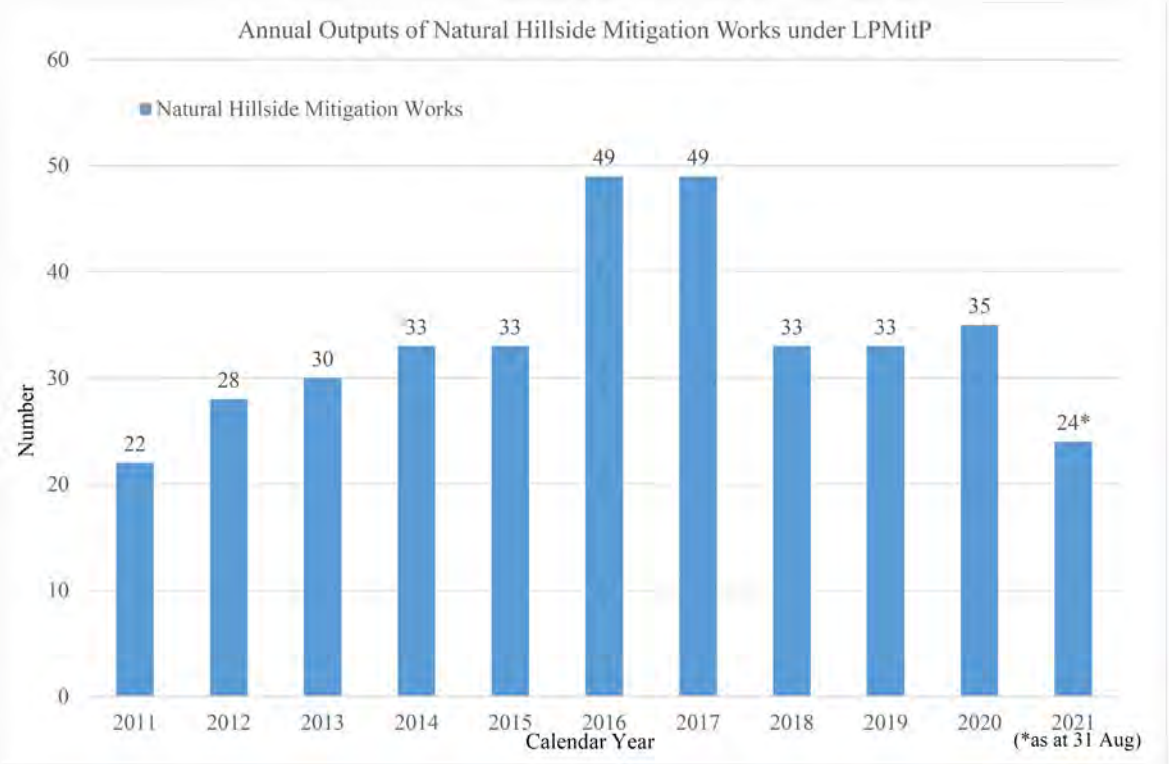
28. CEDD has effectively implemented the LPMitP and meets the pledged annual outputs consistently.

29. Owing to population growth, slope ageing and extreme weather exacerbated by climate change, the landslide risk is increasing with time. CEDD will continue to apply the latest innovation and technology to contain the landslide risk in Hong Kong within a reasonably low level in the long term.

Development Bureau
Civil Engineering and Development Department
September 2021

Annex A


Annual Outputs of Upgrading Works of Government Man-made Slopes and Safety Screening Studies for Private Man-made Slopes under LPMitP
Government Man-made Slopes Upgraded
Safety Screening Studies for Private Man-made Slopes Completed
Number
Calendar Year
(*as at 31 Aug)
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
173 153 153 154 155 165 155 152 165 166 117*
107 107 102 110 102 102 103 100 100 100 60*


Annual Outputs of Natural Hillside Mitigation Works under LPMitP
Natural Hillside Mitigation Works
Number
Calendar Year
(*as at 31 Aug)
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
22 28 30 33 33 49 49 33 33 35 24*