Greater Bay Area

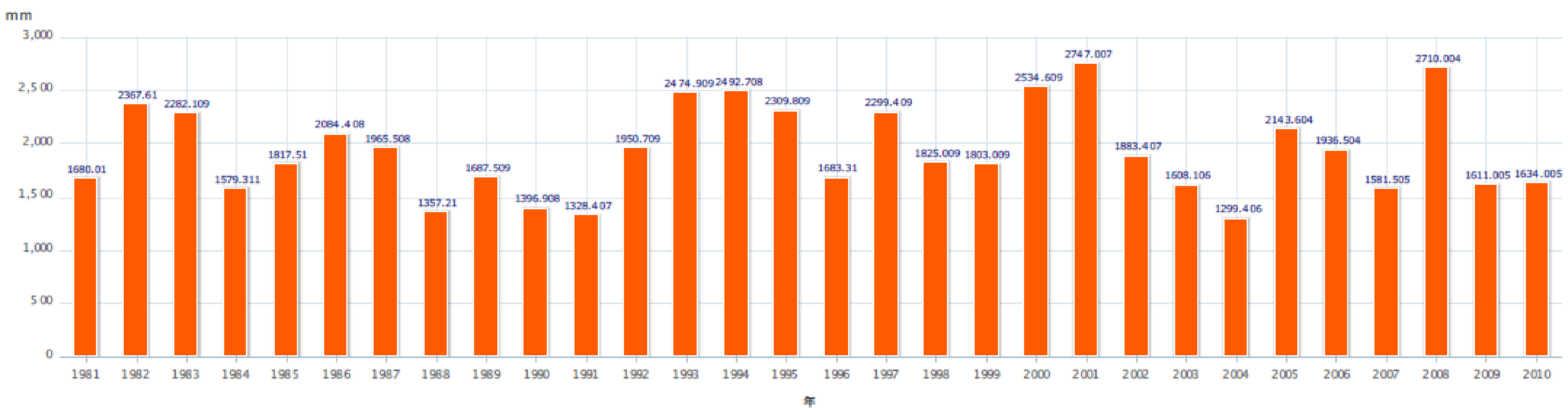
- Hong Kong & Macau
- Guangzhou, Shenzhen, Zhuhai, Foshan, Zhongshan, Dongguan, Zhaoqing, Jiangmen & Huizhou (9 cities in Guangdong Province)

Rainfall

- Annual rainfall: **1600 - 2000 mm**
- Rainy season: April – September

account for approximately **80%** of the annual rainfall

(Overview of Guangdong-Hong Kong-Macao Greater Bay Area, 2017)



Annual rainfall in Shenzhen from 1981 to 2010

(Meteorological Bureau of Shenzhen Municipality, average annual rainfall: 1966 mm)

Disasters in GBA in recent years

2017.02 Jiangmen Tunnel collapse
1 dead

2018.02 Foshan Pavement subsidence
11 dead, 8 injured & 1 lost

2015.12 Shenzhen Landslide
73 dead,4 lost & financial loss of over 0.88 billion RMB

2016.01 Guangzhou
Differential settlement

2016.07 Zhaoqing Torrential flood
8 get trapped

2017.08 Greater Bay Area Typhoon
24 dead & financial loss of 6.82 billion USD

Ground risk

"Several studies have been published over the last 30 years or so that clearly demonstrate that, in civil engineering projects, the largest element of financial and technical risk usually lies in the ground"

(National Research Council 1984; The Institution of Civil Engineers (ICE), 1991; Whyte 1995)

Ground risk

"Cost overruns of up to £516 million were revealed by, the UK Department of the Environment, Transport and the Regions (DETR), in the seven largest road projects executed, due to unforeseen ground conditions, accounting for a 63% increase above budgeted funds. "

(DETR, 2014)

Ground risk

In financial terms, minor design changes can add 5% to the cost of construction, and additional cost as high as 30% to 50% are not uncommon.

If unforeseen ground conditions are encountered during construction, then additional costs as high as 100% of the entire project may be incurred.

(Scott, D. 2012. Director of GroundSolve Ltd.
https://www.geolsoc.org.uk/~/media/shared/documents/specialist%20and%20regional%20groups/southernwales/2%20Risk%20Management%2026th%20Oct%202012%20Debbie%20Scott.pdf?la=en)

Thank You

Typical Geotechnical Profile in GBA

- **Karst**: 2658 km^2 (2.6 times HK area)

  (potential for ground subsidence, high: 415 km^2; moderate: 702 km^2)

- **Soft clay**: 11,187 km^2 (11 times HK area)

  over 10 m depth: 2846.3 km^2; Estuary area in Guangzhou, Zhongshan, Dongguan, Zhuhai and Jiangmen

  over 30 m depth: 325.8 km^2; Estuary area in Zhuhai, Zhongshan, Jiangmen and Guangzhou

(Chinese Territory Resource， www.gtzyb.com/dizhikuangchan/20170801_106478.shtml)

Potential disasters in GBA

- Landslides and debris flows： North and West of province
- Subsidence due to Karst and mining (area 15 times HK)
- Ground settlement (soft clay - consolidation) due to underground water pumping

(https://wenku.baidu.com/view/6931cd5b6bd97f192279e97c.html)

广东省地质灾害的主要类型和特点

- 滑坡：广东地区的滑坡，相比与西南地区的滑坡，规模是比较小的
- 泥石流：主要分布在粤北和粤西地区
- 地面塌陷：分为覆盖型岩溶发育区塌陷和矿山采空区塌陷，易发区面积15314 km^2
- 地面沉降：城市内过量开采地下水引起地面沉降，涉及面极大
- 水土流失：共有70多个县市比较严重（38个县市流失面试超过100 km^2）

(https://wenku.baidu.com/view/6931cd5b6bd97f192279e97c.html)

粤港澳大湾区是指由**香港、澳门**两个特别行政区和广东省的**广州、深圳、珠海、佛山、中山、东莞、肇庆、江门、惠州**九市组成的城市群

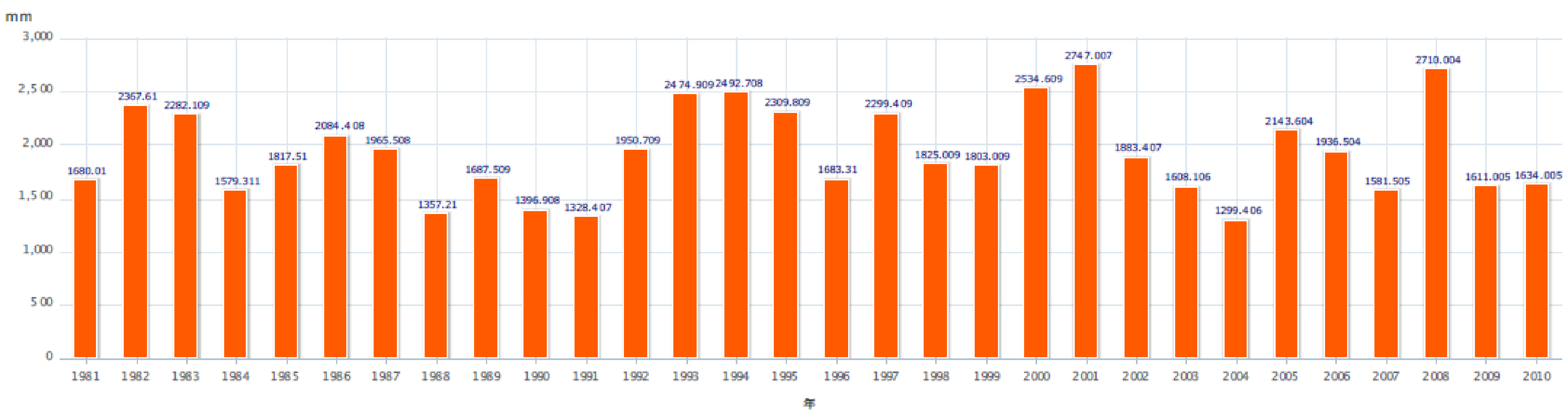
粤港澳大湾区地质情况概述

- 大湾区内**可溶岩**分布面积2658平方千米，其中地面塌陷高易发区面积415平方千米、中易发区面积702平方千米。
- 区内**软土**分布面积11187平方千米，**厚度超过10米**的区域主要分布于广州、中山、东莞、珠海、江门的八大入海口门地区及江门至中山、佛山的部分地区，面积达2846.3平方千米；**厚度超过30米**的区域面积为325.8平方千米，主要分布于珠海、中山、江门和广州的河口地区。

（中国国土资源报，www.gtzyb.com/dizhikuangchan/20170801_106478.shtml）

粤港澳大湾区降雨情况

南亚热带湿润季风气候，**年降雨量1,600-2,000mm**，每年4－9月为雨季，降雨量约占全年的80%左右，降雨年度变化呈双峰型，最高峰在6月，次高峰在8月。（港澳大湾区城市群概览，2017）



深圳市1981-2010年年降水趋势图（深圳市气象局，年平均降水量为1966mm）

粤港澳大湾区近年来发生的灾害

2017.02.25　江门　隧道坍塌
1人死亡

2018.02.07　佛山　路面塌陷
11人死亡，8人受伤，1人失联

2015.12.20 深圳 山体滑坡
73人死亡、4人失踪，经济损失
8.8亿余元

2016.01.12 广州 不均匀沉降

2016.07.12　肇庆　山洪
8人被困

2017.08.23 “天鸽”台风
24人死亡，经济损失68.2亿美元
（大陆：43.8亿，香港：10.2亿，澳门：14.2亿）

"The ground is the place where things are most likely to go wrong during a construction project, and the worse the ground, the greater the risk"

(The Institution of Civil Engineers (ICE), 1991)

Unexpected Ground Conditions

" The amount spent on investigating the ground prior to construction is typically 1% to 5% of the whole project value."

" The costs of claims and additional expenses due to unexpected ground conditions can be as high as 50% of the total cost overrun on the project."

(Hencher 2017, University of Leeds; https://www.hencherassociates.com/app/download/5810023017/web+2017+Unexpected+Ground+Conditions+and+How+to+Avoid+Them+4.pdf)

"The ground is the place where things are most likely to go wrong during a construction project, and the worse the ground, the greater the risk"

(The Institution of Civil Engineers (ICE), 1991)

"Several studies have been published over the last 30 years or so that clearly demonstrate that, in civil engineering projects, the largest element of financial and technical risk usually lies in the ground"

(National Research Council 1984; The Institution of Civil Engineers (ICE), 1991; Whyte 1995)

“50% of the examined 8000 commercial buildings in UK suffered delays due to unforeseen ground difficulties ”

(National Economic Development Office in the UK (NEDO) 1988)

“90% of risk to projects originates from unforeseen ground conditions which could often have been avoided by adequate and full site investigation”

(Alhalby and Whyte 1994)

“Cost overruns of up to £516 million were revealed by, the UK Department of the Environment, Transport and the Regions (DETR), in the seven largest road projects executed, due to unforeseen ground conditions, accounting for a 63% increase above budgeted funds. ”

(DETR, 2014)

"The Hallandsås Tunnel Project, Sweden, designed for the construction of two 8.6 km long railway tunnels at an initial budgeted cost of £440 million in 1992, escalated to £840 million in 2008, due to unforeseen ground and water conditions"

(Creedy, 2006)

"The £900m cost overrun reported in the Big Dig, United States Boston Artery project, were technical issues due to unforeseen ground conditions"

(Creedy, 2006)

Importance of ground investigation

Statistics from Britain demonstrate the importance of adequate ground investigation:

- 30% of construction projects delayed by ground problems
- Unforeseen ground conditions cause most piling claims
- 50% of over-tender costs are due to inadequate ground investigation

(Waltham, T. 2009. Foundations of Engineering Geology, Third edition, CRC Press)

Chapman and Marcetteau (2004) showed that in the UK, about a third of construction projects are significantly delayed and of those, half of the delays are caused by problems in the ground. Applying this ratio to the whole European Union, it would suggest that an annual average cost of 50 billion euro are due to ground-related causes.

Ground risk

There are many different types of hazard in the ground, and the consequences of failing to manage the risks they produce are often severe.

In financial terms, minor design changes can add 5% to the cost of construction, and additional cost as high as 30% to 50% are not uncommon.

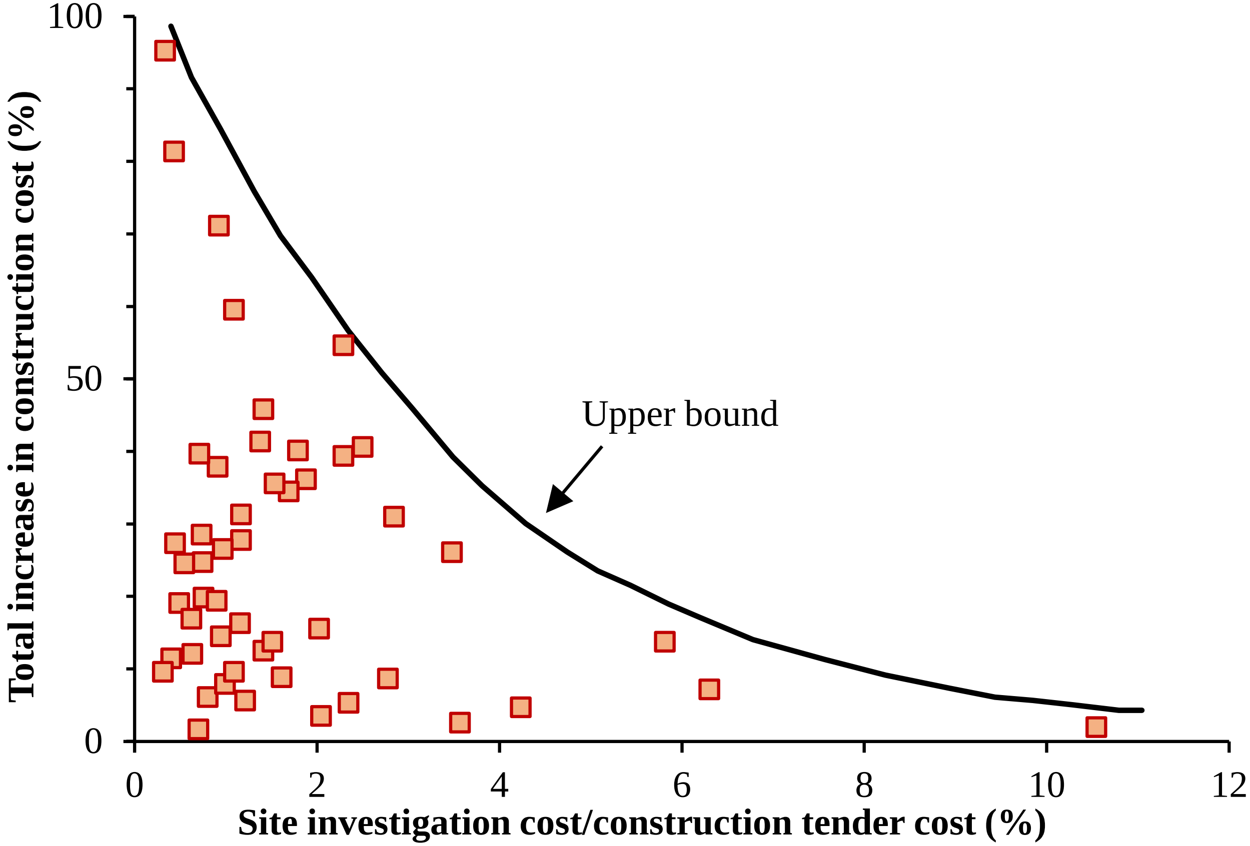
If unforeseen ground conditions are encountered during construction, then additional costs as high as 100% of the entire project may be incurred.

(Scott, D. 2012. Director of GroundSolve Ltd. https://www.geolsoc.org.uk/~/media/shared/documents/specialist%20and%20regional%20groups/southernwales/2%20Risk%20Management%2026th%20Oct%202012%20Debbie%20Scott.pdf?la=en)

Ground risk

Extract from Managing Geotechnical Risk: Improving Productivity in UK Building and Construction, Clayton CRI, 2001

"Less than 1% of the total construction tender price is typically spent on site investigation, and the data shows that cost over runs of up to 100% are then possible, even when high level of skills are used."



Construction risk in Hong Kong

Risk ranking based on an empirical questionnaire survey geared towards clients, contractors and consultants in Hong Kong (Chan et al. 2009).

Rank	Risk factor
1	Change in scope of work
2	Insufficient design completion during tender invitation
3	Unforeseeable design development risk
4	Errors and omission in tender document
5	Exchange rate variations
6	Unforeseeable ground conditions
7	Actual quantities of work
8	Contracting parties lack of experience
……	…………
33	Low productivity of labour and equipment

Unforeseen ground conditions was discerned as a key **physical** risk factor. Shen (1997) also found that unexpected ground conditions constitute a key risk factor leading to project delay in Hong Kong.