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# Effect of Geotechnical Works on Sustainable and Resilient Cities

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## Abstract

The geotechnical works in the cities have great impact on life and prosperity of the people, thus greatly affecting the sustainability and resiliency of the cities. The excavation for utilities, including gas, electricity, telephone lines, fiber optic lines, sanitary and storm sewers, are usually done in separate trenches, and hinder people and traffic and are vulnerable to heavy rains, snow falls and freezing temperatures. Sustainable and resilient cities should have proper planning for unique utility tunnels with redundancy. The excavation for underground metro tunnels, freeways, new intersections and interchanges and street widening has a tremendous impact on comfort and prosperity of the people, and new insights and methods should be implemented to improve the situation for sustainable and resilient cities. The excavation for high rise buildings, which sometimes are up to 40 meter deep and 100 m by 100 m wide with traditional methods of soil nailing and anchoring etc. are basically used to save land adjacent to neighbors and city streets and cause discomfort to the cities. Innovative methods should be applied for sustainable and resilient cities. In this paper examples of traditional and improved methods are presented and guidelines are offered so that the geotechnical works have positive outcome for sustainable and resilient cities.

**Keywords:** resilient and sustainable cities, geotechnical works, utilities, infrastructure, excavation

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# تأثیر کارهای ژئوتکنیکی بر شهرهای پایدار و تاب‌آور

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## چکیده

کارهای ژئوتکنیکی در شهرها تأثیر زیادی بر زندگی و رفاه مردم دارد و درنتیجه، پایداری و تاب‌آوری شهرها را به‌شدت تحت تأثیر قرار می‌دهد. حفاری برای تأسیسات ازجمله گاز، برق، خطوط تلفن، خطوط فیبر نوری، فاضلاب‌های بهداشتی و طوفانی معمولاً در ترانشه‌های جداگانه انجام می‌شود که مانع عبور و مرور مردم بوده و در برابر باران‌های شدید، بارش برف و یخ‌زدگی آسیب‌پذیر است. شهرهای پایدار و تاب‌آور باید برنامه‌ریزی مناسبی برای تونل‌های شهری منحصربه‌فرد با افزونگی داشته باشند. حفاری تونل‌های زیرزمینی مترو، آزادراه‌ها و تقاطع‌های جدید و تعریض خیابان‌ها تأثیر شگرفی بر آسایش و رفاه مردم دارد و باید بینش‌ها و روش‌های جدیدی برای بهبود وضعیت شهرهای پایدار و تاب‌آور اعمال شود. گودبرداری ساختمان‌های مرتفع که گاهی تا عمق ۴۰ متر و عرض ۱۰۰ متر در ۱۰۰ متر با روش‌های سنتی میخ‌کوبی و لنگر انداختن خاک و غیره است، اساساً برای صرفه‌جویی در زمین‌های مجاور همسایگان و خیابان‌های شهر استفاده می‌شود که با ایجاد ناراحتی در شهرها همراه است. برای شهرهای پایدار و تاب‌آور باید از روش‌های نوآورانه استفاده شود. در این مقاله نمونه‌هایی از روش‌های سنتی و اصلاح‌شده و خطوط راهنما ارائه می‌شود تا کارهای ژئوتکنیکی، نتایج مثبتی برای شهرهای پایدار و تاب‌آور داشته باشد.

**کلیدواژه‌ها:** شهرهای مقاوم و پایدار، کارهای ژئوتکنیکی، تأسیسات، زیرساخت‌ها، حفاری

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## Introduction

The urbanization of the world will be unprecedented; by 2050 three-quarters of the world 9 billion population will live in urban environment.

The definitions of resilient and sustainable cities are presented by many authors. The definition presented by "Resilient Sustainable Cities, A future" (Pearson et al, 2014) is quoted here:

"Resilience concerns the capacity of an urban system – including its natural, built, social and economic elements – to manage change, learn from difficult situations and be in a position to rebound after experiencing significant stress or shock, while sustainability questions whether or not certain aspects of our daily activities, and systems within which they operate, can be continued indefinitely into the future, again from a social, economic and environmental perspective."

For infrastructures including geotechnical works in the cities, three horizons are presented by Newton (Newton, 2007) shown in figure 1. And detailed explanation is given in table 1 presented by Newton (Newton, 2012).

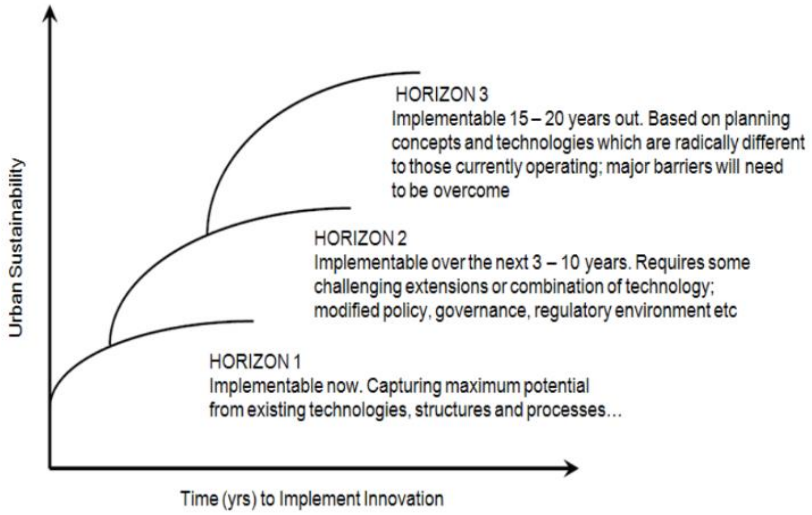


**Fig 1. Three horizons of urban development (Newton, 2007)**

**Table 1. Three horizons of urban innovation (Newton, 2010)**

**3 HORIZONS OF URBAN INNOVATION** (Source: Newton, 2010)

| Urban Environmental Domain | H1 | H2 | H3 |
|---|---|---|---|
| Energy | Energy efficiencies in housing and industry; dwelling energy rating; appliance rating etc | Distributed renewable energy and low emission energy generation systems; methane bridge (substitution of gas for coal) | Renewables-based solar-hydrogen economy |
| Water | Water-smart appliances; domestic rainwater tanks; desalination | Sewer mining; water sensitive urban design | Integrated urban water systems (recycled stormwater, wastewater) |
| Waste | Product stewardship; waste separation and recycling; domestic composting | Extensive cradle to cradle manufacturing based around single enterprises (e.g. motor vehicles, computers, building products etc.) | Eco-industrial clusters based on utilisation of multiple waste streams |

**3 HORIZONS OF URBAN INNOVATION (cont'd)**

| Urban Environmental Domain | H1 | H2 | H3 |
|---|---|---|---|
| Transport & Communications | Road pricing; high speed rail; telepresence via broadband internet communications | Hybrid / electric vehicles; telecomuting, teleshopping, telebanking etc. | Integrated transport and landuse; intelligent transport systems; green transport |
| Buildings | Check-box system for green building design; tall buildings | Real-time life cycle sustainability performance assessment during design; building information models; hybrid buildings | Ultra-smart building and linked infrastructures; green building materials with embedded intelligence |
| Urban Development | Smart Greenfield development | Brownfield development | Comprehensive Greyfield regeneration |

It is clear from above that Geotechnical works have great impact on life and prosperity of the people in the city, thus greatly affecting the sustainability and resiliency of the cities.

In this paper the excavation for utilities, excavation for transportation development and excavation for high rise buildings are presented and innovative methods are discussed.

## Excavation for utilities

The excavation for utilities including gas, electricity, telephone lines, fiber optic lines, sanitary and storm sewers in most cities are carried out after the asphalt pavement is built and they are usually done in separate trenches. Figure 2 shows an example of such utility construction being carried out in one of the Shiraz Boulevards at the same time on two sides of the boulevard.

**Fig 2. utility construction on two sides of a Shiraz Boulevards at the same time.**

The separate trenching hinders people and traffic and are vulnerable to heavy rains, snow falls and freezing temperatures.

It is estimated that up to 7 kilometers of trench are carried out in these streets per kilometer of street length. Thus, the enormous carbon imprint and inconvenience for people are evident.

Sustainable and resilient cities should have proper planning for unique utility tunnels with redundancy.

An example of proper utility construction is shown in figure 3 for city of Mashhad, Iran. These utility constructions should be carried out in modern cities for resilience and sustainability.


**Fig 3. Example of proper utility construction in city of Mashhad, Iran**

## Excavations for transportation networks

The excavation for underground metro tunnels, freeways, new intersections and interchanges and street widening has tremendous impact on comfort and prosperity of the people, and new insights and methods should be implemented to improve the situation for sustainable and resilient cities.

Underground metro tunnels carried out with tunnel boring machines have small carbon imprint.

City of Tehran, Iran is an excellent example of such public metro transportation. It is inconceivable now to imagine Tehran without metro transportation. Other cities in Iran such as Mashhad, Tabriz, Isfahan, and Shiraz are completing metro construction and are planning for future expansion.

Other nations have adopted metro and rail construction. Eight-two Chinese cities are building metros Dingding, (Dingding, 2008). Beijing and Shanghai have metros. In India fourteen cities are building metros: Jain, (Jain, 2008).

Figure 4 shows an example of Tehran Piroozi metro. Figure 5 shows Mashhad metro. Figure 6 shows Shiraz metro.


**Fig 4. An example of Tehran Piroozi metro, Iran**

**Fig 5. Mashhad metro, Iran**


**Fig 6. Shiraz metro, Iran**

Public transportation is an important step in making cities resilient and sustainable. Metro, bus lines and trains are important steps. Another trend which is confronting many Iranian cities is to widen and make new streets. Then start making intersections and interchanges and then burst into making freeways, all of which will not relieve the traffic in our developing cities. Adding new cities around the main city is another trend which will not eventually solve the problem of expansion of the city and traffic. As far as the emphasis is on private passenger cars the problem will worsen and the eventual end is air pollution and devastated environment, and the cities will not be loveable and in many instances will not be livable. In such cities you will not find bicycles and pedestrian pathways and the concept of café city is completely forgotten. Parking spaces become unavailable and traffic congestion becomes daily routine. The whole city looks then like a huge parking space and hours of city occupant are spent in traffic and in bad and polluted air. Because of job attraction, migration to these cities is another serious problem with underdeveloped and unsuitable neighborhoods. Strategies like even and odd day traffic and city center traffic plan often will inconvenience the people and if the strategies do not change into emphasis on public transport the problem persists.

Figure 7 shows the comparison of green spaces in part of Shiraz between 2003 and 2014.

Figure 8 shows beautiful rotary turned into huge interchange at Maaliabad, Shiraz between 2003 and 2014

**Figure 7. The comparison of green spaces in part of Shiraz between 2003 and 2014**

**Fig 8. Beautiful rotary turned into huge interchange at Maaliabad, Shiraz between 2003 and 2014**

Another development in our cities for relieving traffic is to construct intercity tunnels and double deck freeways. Again if the public transport is not developed, these measures will not in the long run relieve the traffic.

Figure 9 shows the intercity tunnel Resalat in Tehran and figure 10 shows the double deck freeway in Isfahan.

**Fig 9. Intercity tunnel Resalat, Tehran, Iran**

**Fig 10. Double deck freeway in Isfahan, Iran**

## Excavation for high rise buildings

The excavation for high rise buildings, which sometimes are up to 40 meter deep and 100 m by 100 m wide with traditional methods of soil nailing and anchoring etc. are basically used to save land adjacent to neighbors and city streets and cause discomfort to the cities. Innovative methods should be applied for sustainable and resilient cities.

Figure 11 shows examples of such excavations. Figure 12 shows the examples of collapse of such excavation.

The top-down excavation process should be implemented to bypass such problems.

The following is taken from Engineer Ali Chaboki (Chaboki, 2014) LinkedIn page about top-down construction.

“Top Down (or Cover-cut) Construction is used in packed plans and is used in Metro Station and Tall buildings as a rapid and effective construction method. In this construction method, the structure and the required retaining structure are connected.

These can be installed in close proximity to existing structure with minimal loss of support to existing foundations. In addition, construction dewatering is not required, so there is no associated subsidence. Top-Down Construction are practically suited in the construction of deep basements, Metro Railway Projects. The "Top Down" method of construction is designated to enable above ground construction work to be carried out simultaneously with the excavation of the basement resulting in significant saving of time on a project."

"The main characteristic of this method is time saving in construction, you can divide the construction in two different parts: 1: upper structure and 2: underground that each can be constructed separately.

Of course, the main element of this method is diaphragm walls as support and foundation.

Last year, we carried out a comprehensive analysis for construction a tall building in Tehran (with 40 story above and 11 underground), finally and we found out the best method and cheaper method is "top-down method with diaphragm walls".

Two methods for excavation considered:

1: traditional excavation (stabilization the walls with ground anchor and shotcrete)

2: The diaphragm walls and top down method (first diaphragm walls and the ground floor slab and then upper structure and …..) the cost was almost equal however;

the second method was one year faster, because the upper structure could start right after ground floor slab, (as its foundation).

In addition, the settlement of the neighbors (for 45 meter excavation was less) and the underground water issue solved by this method"

**Fig 11. Examples of excavations in Tehran, Iran for high rise building construction.**

**Fig 12. Examples of collapse of such excavations taken from lecture by Prof. Fakher of Teheran University (Fakher, 2013)**

## Summary and conclusions

The effect of geotechnical work for resilient and sustainable cities is explained in this paper. The normal utility construction with separate trenches for each utility that sometimes incorporates 7 kilometer of utility trench for each kilometer of street length should be abandoned and tunnel utility construction with redundancy is recommended. The transportation network for resilient cities is emphasized and it is shown that metro and train construction and double deck and city tunnels are promising for resilient and sustainable cities. The deep excavation for tall buildings with normal method of soil anchoring, nailing

is explained, and it is recommended that the method of top-down construction should be planned for these deep excavations for resilient and sustainable cities.

## References

Chaboki, Ali. (2014). LinkedIn page.

Dingding, X. (2008). Blueprint of railways development. *China Daily*, *17*.

Fakher, A. (2013). Factors affecting excavation collapse, Symposium on construction. *Iranian Society of Civil Engineering* [In Persian].

Jain, A. K. (2008) The Delhi metro. *Delhi Development Authority*, Delhi.

Newton, P. W. (2007). Horizon 3 planning: meshing liveability with sustainability. *Environment and Planning B: Planning and Design*, *34*(4), 571-575.

Newton, P. W. (2012). Livable and sustainable? Socio-technical challenges for 21st century. *Journal of Urban Technology*, *19*(1), 82-101.

Pearson, L. J., Newton, P. W., & Roberts, P. (2014). *Resilient and sustainable cities a future*. Routledge.

**استناد به این مقاله:** قهرمانی، ارسلان. (۱۴۰۱). تأثیر کارهای ژئوتکنیکی بر شهرهای پایدار و تاب‌آور. *فصلنامه پژوهش‌های نوین در شهر هوشمند*، ۱(۱)، ۶-۱۴.