多数アンカー式補強土壁協会

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Multi-Anchor Reinforced Soil Wall Method Association

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多数アンカー式補強土壁工法

Multi-Anchor Reinforced Soil Wall Method

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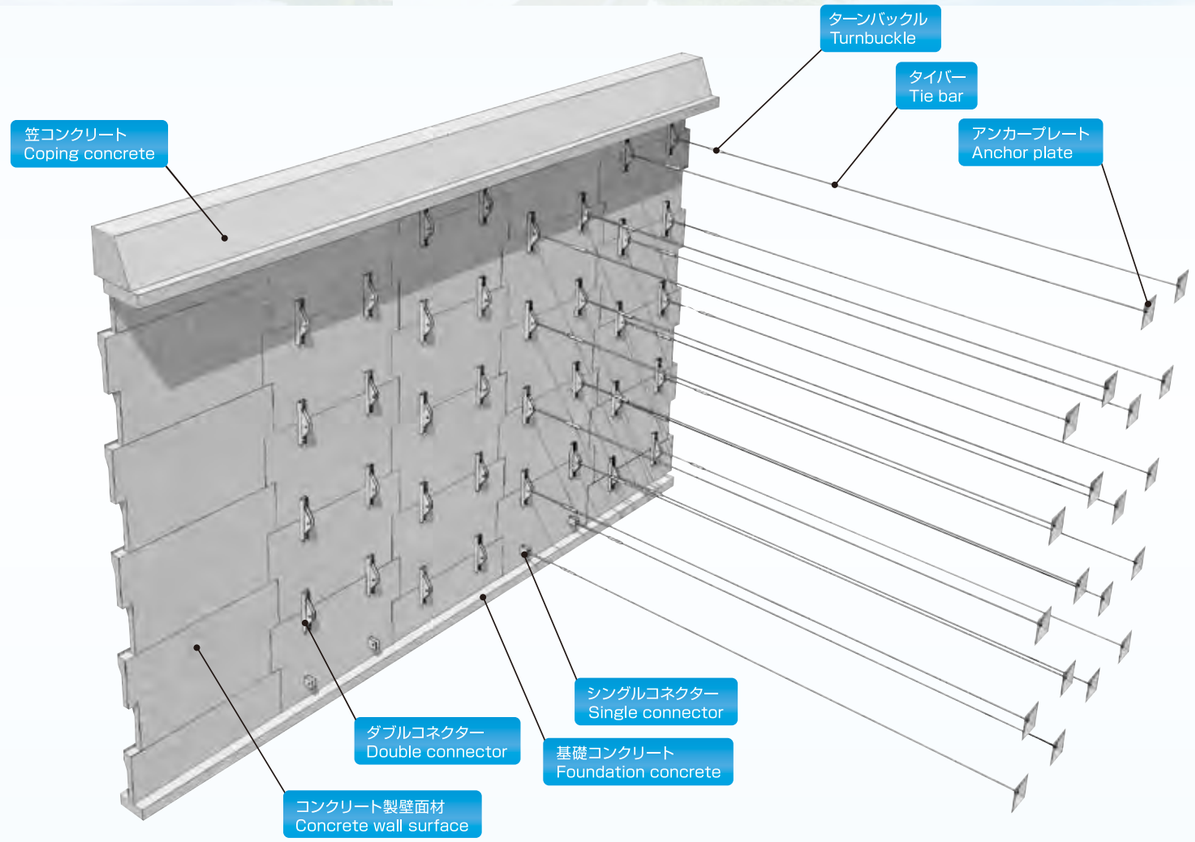
Multi-Anchor Reinforced Soil Wall Method Association

多数アンカーはわが国で独自に　開発された補強土壁工法です

Multi-anchor is a reinforced soil wall construction　method independently developed in Japan

多数アンカー式補強土壁工法は、１９７０年に旧建設省土木研究所にて考案された「杭張材を用いた盛土安定増大工法」を原案とするわが国独自開発の補強土壁工法です。幅広い盛土材を適用できる特性を活かしての建設発生土の有効利用や高い耐震性、環境負荷の軽減、そして優れた安定性を併せ持っています。これまでの３０年以上の実績を踏まえ、２０１４年８月には「多数アンカー式補強土壁工法設計・施工マニュアル第４版」（一般財団法人土木研究センター）が発刊され、ますます信頼性が向上しました。

The multi-anchor reinforced soil wall construction method is based on the "fill stability improvement construction method using tensile member" invented by the former Ministry of Construction Public Works Research Institute in 1970. Its ability to be applied to a wide variety of backfill materials allows for the efficient use of surplus soil, provides strong earthquake protection, reduces environmental burdens, and offers superior stability. Looking back over 30 years of results in applying the method, the "Multi-Anchor Reinforced Soil Wall Construction Method Design/Construction Manual Edition 4" (Public Works Research Center) was published in August 2014. The construction method continues to grow even more reliable.



時代とともに進化する多数アンカー式　補強土壁工法の6つの特長

The six advantages of the multi-anchor reinforced soil wall　construction method, which continues to evolve with the times

1 現場発生土の有効利用

Effective use of surplus on-site soil

補強のメカニズムからも、現場発生土を最大限利用できる工法のため、砂質土、岩ズリ、礫質土、粘性土などの有効活用が可能です。道路計画のゼロエミッションの推進に有効な工法です。

The reinforcement mechanism allows for the optimal use of surplus on-site soil, meaning sandy soil, rock muck, gravelly soil, cohesive soil, and more can be used effectively. The construction method is also effective in promoting zero-emissions in road projects.

2 掘削量削減「ロックアンカー」

"Rock anchor" reduces excavation volume

補強領域背面の岩盤が強固な場合は、ロックアンカーとの併用で掘削土量の削減を有効にします。現場発生土の抑制を推進するわが国の施策をふまえた合理的な工法です。

Multi-anchor can be used with rock anchors when natural ground behind the reinforced soil wall is solid bed rock,effectively reducing the amount of soil to excavate. This economical construction method matches the Japanese policies to control the amount of surplus on-site soil.

3 工期短縮と安全性

Shorter construction period and safety

タイバーに組み込んだターンバックルにより壁面の鉛直度調整が容易です。また、部材は全て工場製作のため、工期短縮が図れます。全ての作業が盛土上でできることから険しい傾斜地での施工もスムーズ。工事の安全性を高めています。

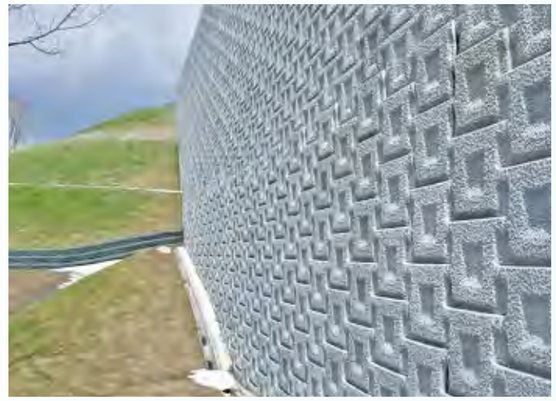
Turnbuckles incorporated into tie bars make it easy to adjust the perpendicularity of wall surfaces. All components are factory-made, for reduced construction period. All operation is possible on backfills, for smooth construction on steeply sloping ground. This makes construction safer.

4 確かな構造安定性

Reliable structural stability

近年頻発する大型地震の震源地近くの実態調査でも、その優れた性能が確認され、極めて安全で安定した工法であることを実証しました。これまで、最大壁高 25m 超の実績があります。

Multi-anchor's superior performance has been confirmed even during surveys near the epicenters of recent large-scale earthquakes, proving that it is an extremely safe and secure construction method. There are cases where walls with a maximum height exceeding 25 m have had been built using multi-anchor.



5 幅広い盛土現場に

Supports a wide variety of fill shapes

用地確保が困難な都市部から、河川断面を侵せない峡谷部の付替え道路まで、あらゆる盛土の現場に適応します。垂直壁を雛壇状に構築する多段盛土や、壁面材で土を挟み込む両面盛土などの計画も可能です。

Multi-anchor is applied to a wide variety of fill sites, from urban areas where site procurement is difficult, to replacement roads in ravine areas that cannot enter river cross-sections. A variety of projects are possible, such as multistage fills where vertical walls are built in tiered platform shapes, or two-sided fills that confirm soil in wall surface materials.

6 維持管理・補修

Maintenance management and repair

これからのインフラ長寿命化を見据え、維持管理方法をマニュアル化し、点検、記録項目を明確化しています。コンクリート製壁面材の軽微なひび割れや断面欠損も容易に補修可能です。

In anticipation of future infrastructures with longer service lives, maintenance methods are being formalized into a manual, while inspection and recording items are being clarified. Slight cracks and partial damage in concrete wall surface material can also be easily repaired.

盛土現場のニーズに対応

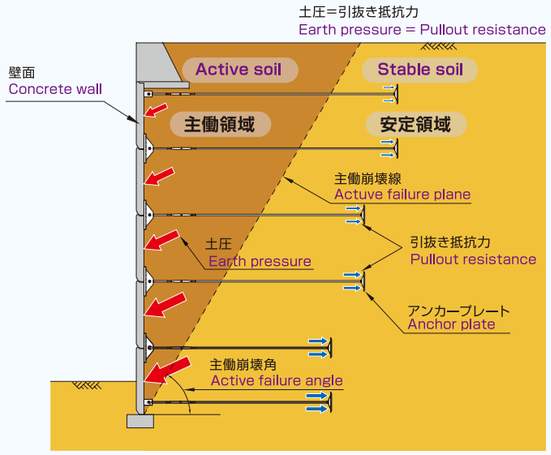
Supports construction site needs

柔軟な発想の柔構造

Flexible structures from flexible ideas

本工法は、壁面材と土中に設置した多数のアンカープレートとをタイバーで緊結することにより直壁を有する土構造物を構築するもので、壁面に作用する土圧と釣り合う引抜き抵抗力で土が拘束補強されるため、様々な盛土現場で幅広く活用されています。

In this construction method, the wall material and multiple anchor plates installed in the earth are bound with tie bars to build an earth structure with a vertical wall. The earth pressure acting on the concrete wall surface and proportional pullout resistance restrains and strengthens the earth. This allows this construction method to be used at a variety of embankment sites.



さらなる技術の革新

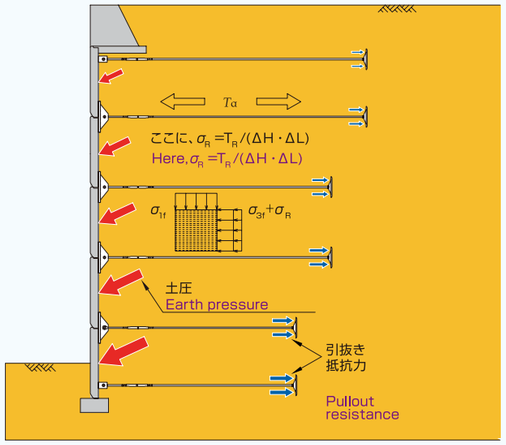
Continuing innovation

1983 年の初採用以来、施工件数は 7,000 件以上、累計壁面積 180 万㎡超の実績を挙げ *、一層の品質向上と研究開発に努めています。その結果、優れた耐震性を安定計算に反映させるとともに性能設計の概念を導入。さらに、現場発生土の有効活用やロックアンカーの使用による地山掘削の低減を推進してきました。従来の摩擦系補強土壁工法と異なる理論に立脚した「多数アンカー式補強土壁工法設計・施工マニュアル」が 1994 年に発刊され、その後、部材改良や技術革新に伴い、第２版、第３版、第４版と継続的な研究がなされています。

* 2015 年３月現在。

Since it was first used in 1983, the multi-anchor construction method has been used in over 7,000 construction projects with a cumulative total wall surface area of 1.8 million m²*. The construction method continues to be researched and developed in order to improve quality even further. As a result, the method's superior earthquake resistance can now be factored into stability calculations, and a concept of performance design has been introduced. The construction method has also promoted reduced earth excavation through the effective utilization of on-site soil and the use of rock anchors. The multi-anchor construction method is based on logic that differs from that of friction-based reinforced soil wall construction methods. The "Multi-Anchor Reinforced Soil Wall Construction Method Design/Construction Manual (Public Works Research Center)" was therefore published in 1994, and research has continued since then, with Editions 2, 3, and 4 published along with component improvements and technological advances.

* As of March 2015



様々な盛土材への適応

Adapts to a variety of fill materials

粘性土
Cohesive soil

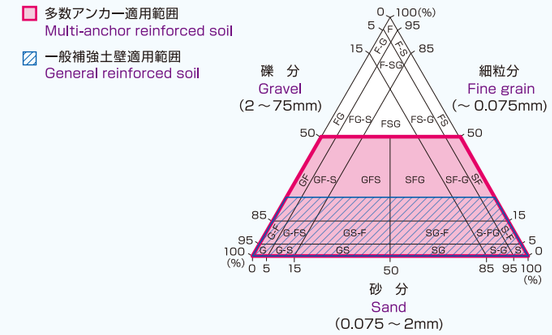
砂質土
Sandy soil

人工軽量盛土材
Artificial lightweight backfill material

エアモルタル
Aerated mortar

多数アンカー式補強土壁は，アンカーの支圧抵抗力を拠所とすることから、粒度の大きい岩から細粒土などの現場発生土まで様々な盛土で補強土を構築することができます。

Multi-anchor reinforced soil walls are based on anchor plate bearing resistance. This makes it possible to build reinforced soil walls on a variety of backfill materials from highly granular surplus on-site soil to aerated mortar.



岩ずりは最大限に活用する

Optimal use of rock muck

多数アンカー式補強土壁は、アンカープレートの支圧抵抗により安定を図ることから、岩ずり等の礫質材料もそのまま盛土材として使用することができます。
※最大粒径の規定あり。

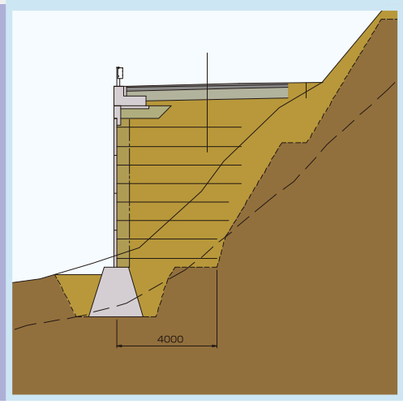
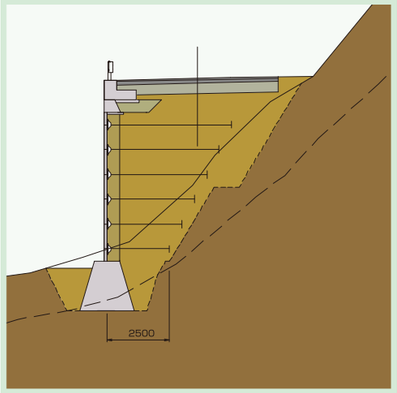
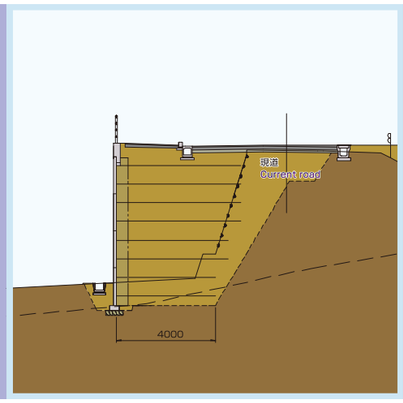
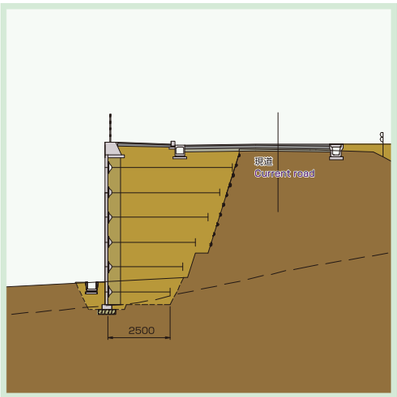
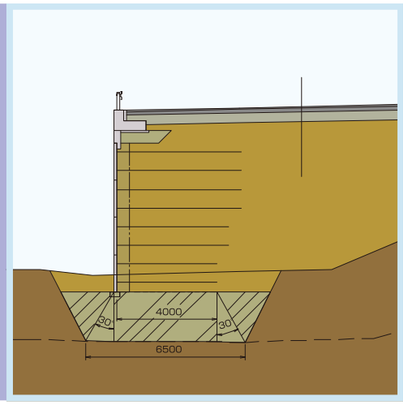
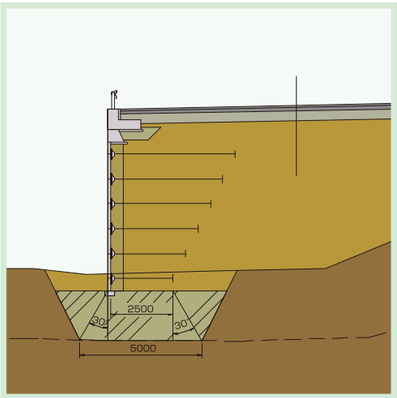
Multi-anchor reinforced soil walls attempt to reach stability via the bearing resistance of the anchor plate, and can use detritus and other gravelly materials as is for backfill materials.
* The maximum grain diameter is regulated.

補強材長の利点

The Reinforcement Material Length Advantage

土木研究センターから発刊されている補強土壁の設計・施工マニュアルのなかでも、多数アンカーは最も補強材長さが短い工法です。
補強材が短いことにより、補強土壁外の要因でも経済性を発揮します。

Among the construction methods described in reinforced soil wall design/construction manuals published by Public Works Research Center, multi-anchor has the shortest reinforcement material length.

	一般的な補強土壁 General reinforsed soil wall	多数アンカー式補強土壁 Multi-anchor reinforced soil wall
山岳道路の掘削低減 Reduced excavation of mountain roads		
現道拡幅時の現道確保 Existing roads secured during widening of said roads		
地盤改良を伴う場合の改良範囲の縮小 Narrower improvement area when improving foundations		

施工手順

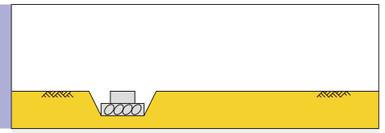
Procedures

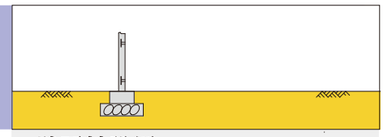
多数アンカー式補強土壁工法は、現場規模にかかわらず少人数での施工が可能で、しかも、壁面材の設置を先行しながら盛土上で作業を行うため、施工中の安全が図れます。土と一体化して構造物を安定させる本工法は、土の工学的特性を有効活用するため、まき出し・転圧等の作業は、多数アンカー式補強土壁設計施工マニュアル第４版(平成26年８月)に沿って施工してください。

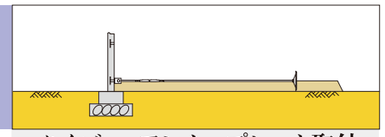
The multi-anchor reinforced soil wall construction method requires only a few workers to perform, regardless of the scale of the site. It can also offer improved safety, as work can be performed on the backfill while at the same time prioritizing the establishment of wall surface materials. This construction method stabilizes structures by integrating them with the soil, and makes effective use of the engineering characteristics of earth. Therefore, be sure to follow the construction procedure in the "Multi-Anchor Reinforced Soil Wall Design/Construction Manual Edition 4 (August 2014)" for work such as spreading soil and surface compaction.

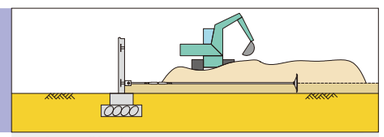
機　種	規　格	台数	備　考
トラッククレーン	油圧式 4.9ｔ級	1	壁面材吊込み
ブルドーザ	11ｔ級	1	盛土材のまき出し、敷均し
バックホウ	0.45m³	1	壁面際の盛土材料のまき出し
タイヤローラ	８～20ｔ級	1	盛土材料の締固め
振動ローラ	ハンドガイド式 1.0ｔ級	1	壁面際の盛土材料の締固め

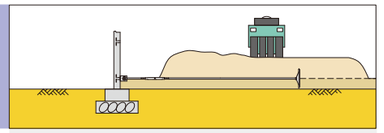
Equipment	Type	Qty	Purpose
Truck crane	Hydraulic 4.9t	1	Panel hanging
Bulldozer	11t	1	Spreading/laying filler
Backhoe	0.45m³	1	Spreading filler aside the wall
Tire roller	8 to 20 t	1	Compaction of filler material
Vibrating roller	Hand-guided type 1.0 t	1	Compaction of filler material on wall surface edges

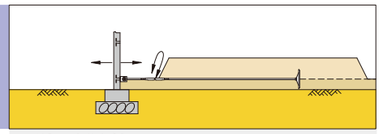
1

基礎
Foundation

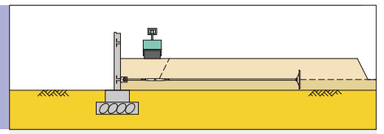
2

壁面材設置
Wall surface material application

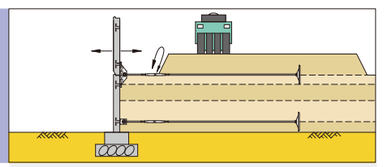
3

タイバー、アンカープレート取付
Connecting tie bar and anchor plate

4

土の敷均し
Soil spreading

5

転圧
Compaction

6

壁面調整
Wall surface adjustment

7

転圧（壁背面）
Compaction (wall rear surface)

8

繰返し
Repeat the process

施工上の注意

- 使用するボルト、ナットは設計で指示されたものを指示された箇所にのみ使用してください。
- 設計に使用した土質条件より低品質な盛土材料で施工しないでください。
- 盛土材料が設計値と異なる場合は、多数アンカー式補強土壁協会までご相談ください。

Construction precautions

- Use only bolts and nuts indicated in the design, and only in indicated locations.
- Do not use backfill materials that are of lower quality than the soil quality conditions in the design.
- Contact the Multi-anchor Reinforced Soil Wall Association if backfill materials differ from design values.

安全な国づくりの一翼を担う耐震性能

Anti-earthquake performance to help build a safe nation

近年頻発する大規模地震や豪雨の際には、補強土壁工法の被災状況の確認・調査がその都度実施されています。その結果は設計・施工の貴重な情報として活かされ、高い安全性の確立に向けた改良に反映されます。
かたや実際の被災現場においては、補強土壁の復旧を図るうえで、体系的な性能評価が必要不可欠になり、特に構造物の管理者は、客観的に補強土壁の被災度の評価、さらには災害復旧に際しての種々の判断や作業を迅速に行う必要が生じ、その指標となる基準が求められていました。
そこで平成 17 年、(財) 土木研究センターにより「補強土工法の被災度評価および災害復旧に向けての基本方針に関する報告書」がまとめられました。

The level of damage suffered by structures built using reinforced soil wall construction methods are confirmed and surveyed whenever there is a large-scale earthquake or torrential rain disaster. There have been many such disasters recently. These results serve as valuable design and construction information, and are used in making improvements to methods with the goal of realizing a high level of safety.
Meanwhile, systematic performance evaluations are essential in attempting to restore reinforced soil walls damaged at actual disaster sites. In particular, structure managers must objectively evaluate the level of damage suffered by reinforced soil walls during disasters, and must quickly make a variety of decisions and perform many tasks in recovering from a disaster. This requires that guidelines be set that can act as indicators used in making such decisions.
In response, the Public Works Research Center prepared the "Report on Disaster Damage Level Evaluation for Reinforced Soil Construction Methods and Basic Policies toward Disaster Recovery" in 2005.

新潟県中越地震や東日本大震災で実証された高い耐震性能

Strong earthquake resistance proven during the Niigata Chuetsu Earthquake and Great East Japan Earthquake

平成 16 年 10 月に発生した新潟県中越地震では、中越地方に施工されている 46 の物件について影響を調査。各地の盛土構造物や擁壁が機能を失い、道路が寸断されているのが確認される中、補強土壁により構築された道路に壊滅的な状況を示す事例は見当たりませんでした。
平成 23 年 3 月 11 日に発生した東北地方太平洋沖地震では、震度 6 弱以上を記録した岩手・宮城・福島・茨城・栃木の 4 県における被災状況を調査しました。その結果、コンクリート壁面材同士が激しくぶつかり合ったと思われる角欠けやクラック、笠コンクリートの山側への傾斜などが見られましたが、補強土壁自身が安定性を損なうような損傷や変状は一切なく、道路としての使用に問題が生じた場所はありませんでした。

被災台帳
Disaster registry

被災度応急判定表
Disaster damage level emergency aid decision table

A survey was conducted on 46 sites in the Chuetsu region that were impacted by the Niigata Chuetsu Earthquake that struck in October 2004. Surveyors confirmed that reinforced soil wall structures and retaining walls in each area lost functionality, while roads were torn to pieces. However, there were no cases noted in which there was catastrophic damage to roads constructed with reinforced soil walls.
A survey on the extent of damage suffered during the Great East Japan Earthquake on March 11, 2011 was conducted in four prefectures (Iwate, Miyagi, Fukushima, and Ibaraki) that recorded earthquakes at an intensity of at least six lower. Results showed corner chipping and cracking (likely due to concrete wall surface materials violently crashing against each other), slanting coping concrete mountainsides, and other damage.
However, there was no sign of damage or deformation that could result in reduced stability in actual reinforced soil walls, and there were no locations with damage that could hinder their use as roads.

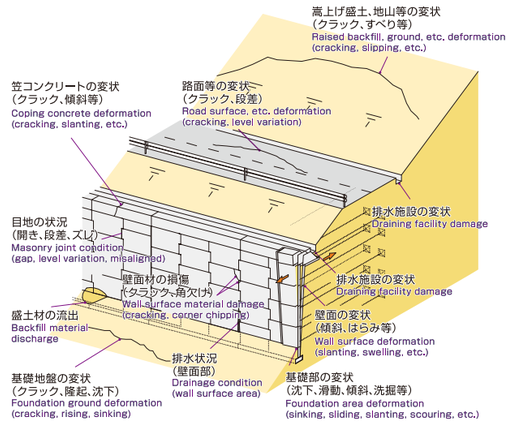
被害が発生した従来擁壁(左手前)と、持ちこたえた多数アンカー式補強土壁(右奥)。
Common retaining wall that suffered damage (left side, toward the front), and a multi-anchor reinforced soil wall that held up (right side, toward the rear).

長寿命化を見据えた維持管理

Maintenance methods for extending lifespans

多数アンカー式補強土壁法自体はきわめて安定的なものですが、供用期間中に機能を良好状態に保ち災害を未然に防止することを目的とした維持管理が必要です。これからの土木構造物が維持管理に軸足を置く必要があることを重視し、平成 26 年に改訂された「多数アンカー式補強土壁工法設計・施工マニュアル」においても新章を設け点検項目・点検方法・修復方法などの維持管理手法を提示しています。

Although the multi-anchor reinforced soil wall construction method itself is extremely stable, maintenance management is required to keep soil walls functioning well when they are being shared and to prevent them from being damaged during disasters. Under the realization that maintenance management is important for civil engineering structures, the "Multi-Anchor Reinforced Soil Wall Construction Method Design/Construction Manual" was revised in 2014 with a new chapter on maintenance management that includes topics such as inspection items, inspection methods, and repair methods.



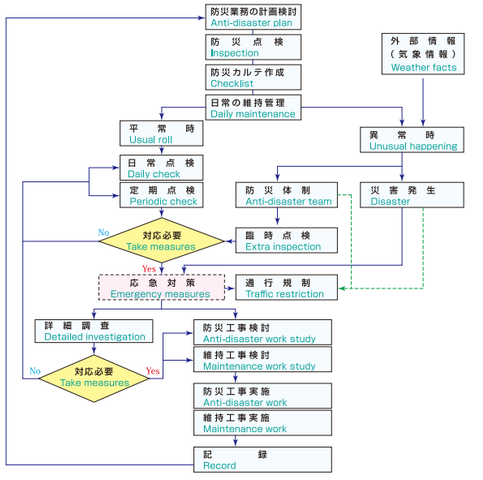
壁面材の補修　Wall surface material repair

多数アンカーは壁面材の補修・交換が可能であり、「多数アンカー式補強土壁工法設計・施工マニュアル第４版」(財団法人土木研究センター) に詳しく記載されています。また、補強材の引抜き試験による擁壁健全度の確認も行うことができます。

Multi-anchor allows for repairing and exchanging wall surface material. This is described in detail in "Multi-Anchor Reinforced Soil Wall Construction Method Design/Construction Manual Edition 4" (Public Works Research Center). The soundness of a retaining wall can also be confirmed by conducting a drawing test on the reinforcement material.

状　態	対応の目安	補修事例
壁面材のクラック	クラック幅 w 0.005c=0.1 ㎜	樹脂充填
壁面材の損傷	角欠けの発生等	断面修復
壁面材の変位	0.03H かつ 30cm	壁面材取替 後打ちアンカー
施工中・施工直後の不出来	0.03H かつ 30cm	撤去、再構築

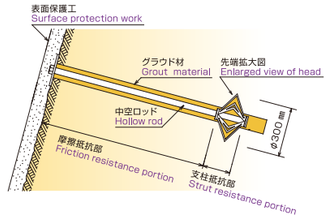
Status	Response guidelines	Repair examples
Wall surface material cracking	Crack width w 0.005 c = 0.1 mm	Fill with resin
Wall surface material damage	Edge chipping, etc.	Cross-section repair
Wall surface material displacement	0.03 H and 30 cm	Replace wall surface material Drive anchors in
Poor execution during/after construction	0.03 H and 30 cm	Remove and rebuild



補強材の増強　Enhancement of reinforcement materials

盛土の安定性の問題や補強材の異常等が認められた場合は、グラウンドアンカーやミニアンカーを新たに補強材として増強することも可能です。

When a problem with the stability of the embankment, an abnormality in the reinforcement material, or some other problem is recognized, ground anchors or Mini-anchors can be added as new reinforcement material.



メンテナンスサイクル

Maintenance cycle

これからの土木施設はメンテナンスの容易さが重要な要素です。多数アンカー式補強土壁協会では、ドローンによる劣化診断が可能な新部材の開発など、様々な面からメンテナンスをサポートします。

The ease of maintenance will be an important element for civil engineering facilities from now on. For multi-anchor reinforced soil walls, we support maintenance work from various aspects such as inspection using drones, and the development of new members and materials that enable deterioration diagnosis.

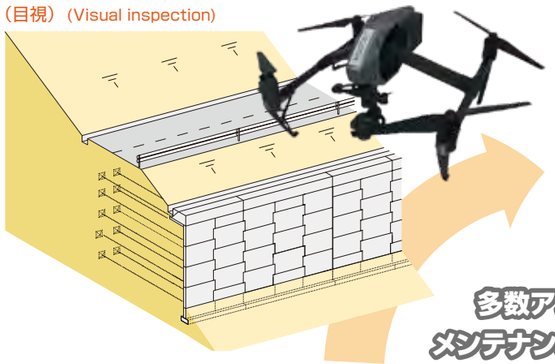
メンテナンスの各フェーズとオプション Phases and options for maintenance

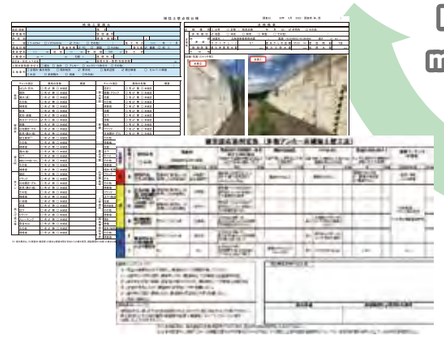
点検 Inspection

多数アンカー構築後、ドローンを活用して壁面の立ち具合を撮影し、初期値として記録が可能です。

After constructing the Multi anchor reinforced wall, we can use drones to obtain images of how the wall surface is standing and keep a record of that as the initial values.

（目視）(Visual inspection)





診断 Diagnosis

実際に機能している鋼製部材の健全性を、非破壊により診断できる壁面材を開発。壁面材を破壊することなく、様々な検査が可能です。

We have developed wall surface materials that enable the non-destructive diagnosis of the soundness of actually functioning steel reinforcements. Various inspections are possible without destroying the wall surface materials.

多数アンカー
メンテナンスサイクル

Multi-anchor wall
maintenance cycle

記録 Recording

点検者の違いや各補強土の違いによって判定基準にばらつきが生じないよう、判定方法や記録方法を提案。

We propose judgment methods and recording methods to ensure that the judgment criteria do not vary between different inspectors or between each reinforced soil location.

措置 Action

盛土の安定性の問題や補強材の異常が認められた場合は、グラウンドアンカーやミニアンカーを新たに補強材として増強することが可能。

If it is recognized that there is a problem with the stability of an embankment, or an abnormality in the reinforcing materials, then it is possible to increase the strength by newly adding ground anchors or mini-anchors as reinforcing materials.

診断対応型でできること

The possibilities for the diagnosis support

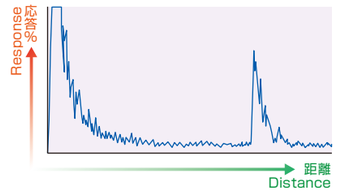
補強土壁は一般に、その安定を確保するうえで非常に重要な構成部材である補強材が盛土材の中に埋設されており、供用後にモニタリングができないという維持管理上の課題を有しています。そこで開発されたのが、補強材を突出させ壁面を外から支持する「診断対応型」。実際に構造を支えている補強材に対して引張試験や各種の非破壊検査を容易に実施することが出来ます。

In general, the reinforcing materials on reinforced soil walls are buried inside the banking material as constituent parts that are extremely important for the securing of stability. The problem for their maintenance and management is that it is not possible to conduct monitoring after they are put into use. The “diagnosis support” was developed in response to this and has reinforcing materials protruding out so that they support the wall surface from the outside. This makes it easy to implement tensile testing and various non-destructive inspections on the reinforcing materials that are actually supporting the structure.

非破壊検査 Non-destructive inspections

超音波探傷法 (補強材破断・欠損診断)
Ultrasonic flaw detection (Reinforcing material fracture or loss diagnosis)

観測波形例
Example waveform observed



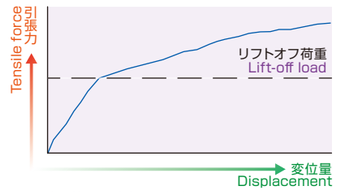
1 超音波探触子をタイバー端部に押し付けて入力した超音波の応答を測定する。
The ultrasonic probe is pressed against the end of the tie bar and measures the response to the ultrasonic wave that was input.

2 超音波の応答が所定のタイバーの長さの位置にあり、かつ他の位置に応答がない場合は、タイバーは損傷していないと診断する。
If the response to the ultrasonic wave is at the designated tie bar length position, and also there is no response at other points, then the diagnosis is that the tie bar is not damaged.

3 超音波の応答が所定のタイバーの長さの位置にない場合は、タイバーが損傷していると診断する。
If the response to the ultrasonic wave is not at the designated tie bar length position, then the diagnosis is that the tie bar is damaged.

リフトオフ試験 (補強材張力診断)
Lift-off tests (Reinforcing material tension diagnosis)

荷重～変位関係の例
Example of relationship between load and displacement



※適用範囲：壁高8m程度以下
*Scope of application: Wall height around 8 m or less

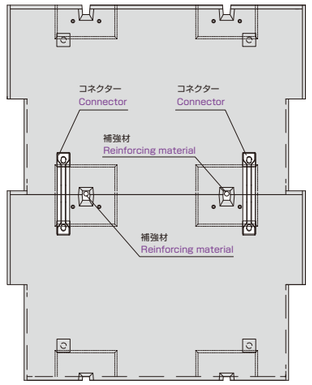
1 壁面材から突出している補強材に対し、頭部にテンションバーを取付け架台、油圧ジャッキ、荷重計、及び変位計を設置する。
A tension bar is attached to the head of the reinforcing material protruding from the wall surface material, and a frame, a hydraulic jack, a load indicator and a displacement gage are installed.

2 引張力を段階的に載荷する。
The tensile force is loaded gradually.

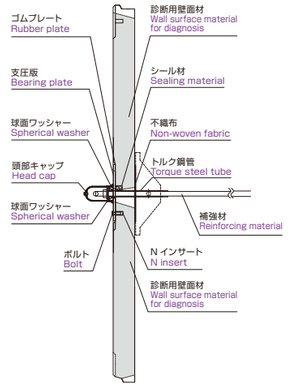
3 荷重～変位関係からリフトオフ荷重を判定し、現在タイバーに作用している張力を測定する。
The lift-off load is judged from the relationship between load and displacement and the tension on the tie bar at the current time is measured.

上下の壁面材はダブルコネクターにより連結
The upper and lower wall surface materials are joined with double connectors

背 面 図
Rear view

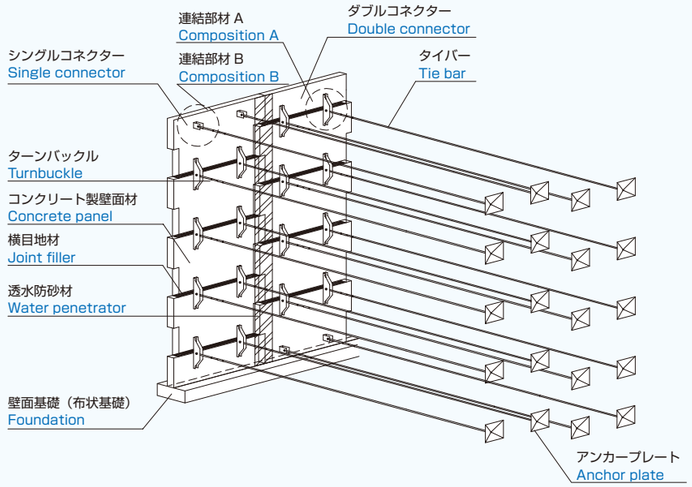


側 面 図
Side view

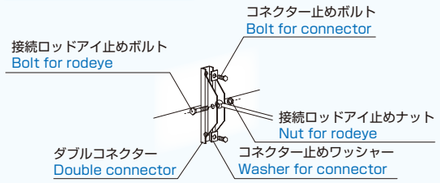


部品・規格寸法
Plans of parts/final view

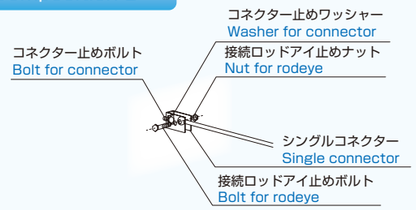
各部名称（全体）
Layout in general



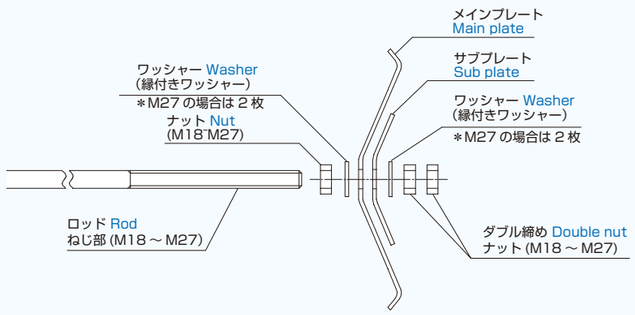
連結部材 A 詳細図
Composition A



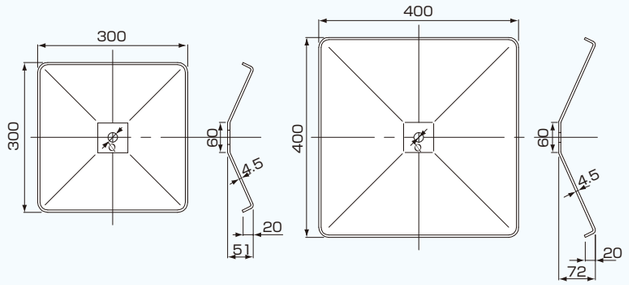
連結部材 B 詳細図
Composition B



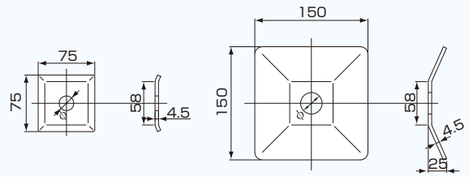
各部名称（プレート部）
Anchor plate composition



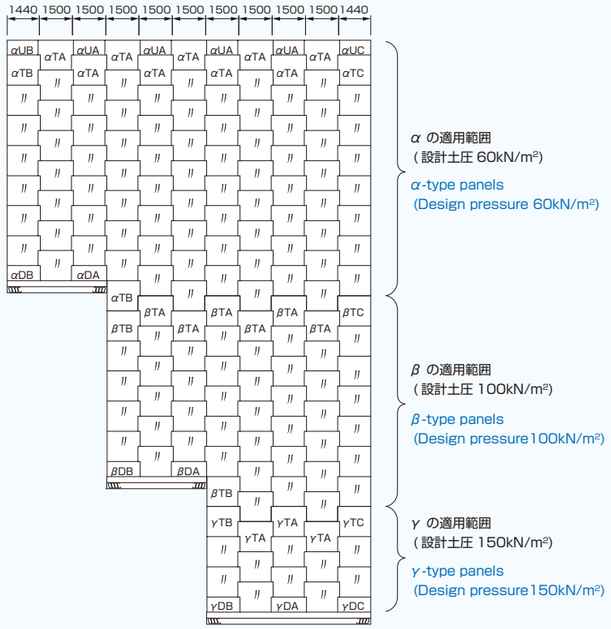
メインプレート
Main plate



サブプレート
Sub plate



組立図例と使用パネル
Standard panel applications

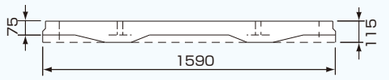


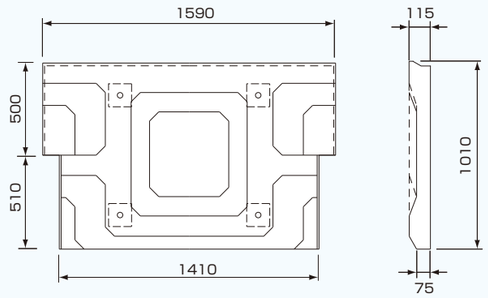
α の適用範囲
（設計土圧 60kN/m²）
α-type panels
(Design pressure 60kN/m²)

β の適用範囲
（設計土圧 100kN/m²）
β-type panels
(Design pressure100kN/m²)

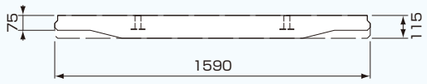
γ の適用範囲
（設計土圧 150kN/m²）
γ-type panels
(Design pressure150kN/m²)

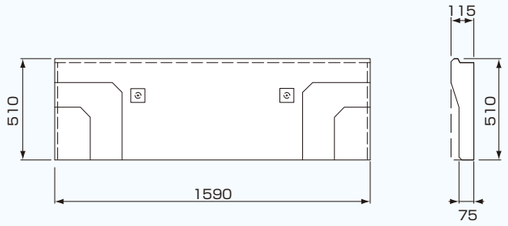
壁面材（TA タイプ） 重量 351 kg
Concrete panel (TA type) weight: 351 kg





壁面材（DA タイプ）重量 200kg
Concrete panel (DA type)　weight: 200 kg





壁面材（UA タイプ）重量 183kg
Concrete panel (UA type)　weight: 183 kg