RITE GEOSYSTEMS

ENCARDIO RITE METASENSING FOR MEGA STRUCTURES

APPLICATION NOTE

ONLINE MONITORING OF BUILDINGS, MONUMENTS, STRUCTURES & BRIDGES

1 INTRODUCTION

Encardio-rite offers online web based monitoring services for the following:

- Safety of existing multiple storey buildings, hotel complexes, corporate offices and buildings of critical importanc
- Safety of old and depleted buildings and structures subject to long-term movement or degradation of materials and monuments/structures of historical importance
- Safety of structures (buildings, monuments, bridges, existing tunnels) during nearby construction activity like construction of Metros, deep excavation for high rise buildings etc.
- Safety of buildings and structures in hills and landslide prone areas

2 STRUCTURAL MONITORING SOLUTIONS

For buildings, structures and bridges etc., it is recommended that Structural Health be continuously monitored to ensure proper maintenance and safety of man and material. A basic system offered by Encardio-rite that can be used for most structures essentially consists of the following:

- Encardio-rite model ESDL-30MT SDI-12 data logger with in-built tiltmeter mounted at one or more locations on the structure to measure and log tilt data (ideally at an indoor location or in shade to prevent effect of large temperature fluctuations on the monitored results). ESDL-30MT is provided with an integral GSM/GPRS modem for storing and transmitting data to a server with the service provider.

- Encardio-rite model EDJ-40V vibrating wire crack meter (with ESVI-01-01 SDI-12 interface box) to monitor structural cracks

- Encardio-rite model EAN-93M-B biaxial tilt meter with integral SDI-12 protocol (at additional locations, if required)

- Crack meters and additional tilt meters can be connected to nearest ESDL-30MT.

- Some other surface and subsurface sensor that may be used depending upon the structure to be monitored and its location are given below. Subsurface monitoring gives important information on ground/soil movement which may affect the stability of the structure.

- Encardio-rite model EDS-70V vibrating wire type multiple point borehole extensometer (with ESVI-01-04 SDI-12 interface box) for monitoring sub-surface settlement and lateral movement at specified points.

- Encardio-rite model ELC-30S resistive strain gage type centre hole load cell (with ESBI-10 SDI-12 interface box) for monitoring tension in anchors used for stabilizing the slope.

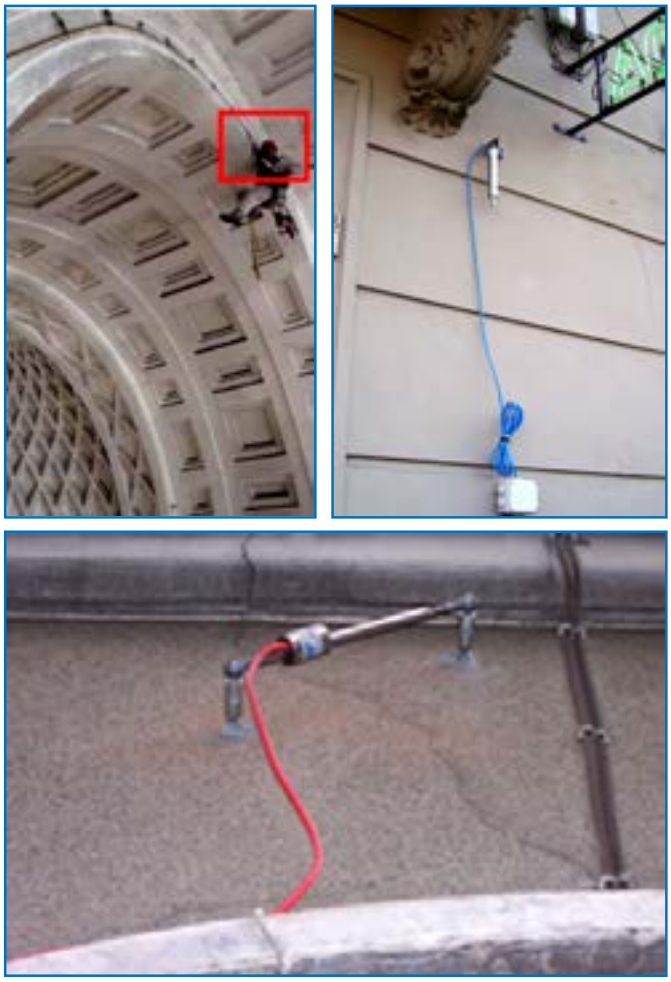
- Encardio-rite model EPP-30V vibrating wire piezometer (with ESVI-01-01 or ESVI-10VB SDI-12 interface box) to monitor sub-surface water level. In case atmospheric pressure is to be monitored, use the model ESVI-10VB as it has an integral barometric pressure sensor.

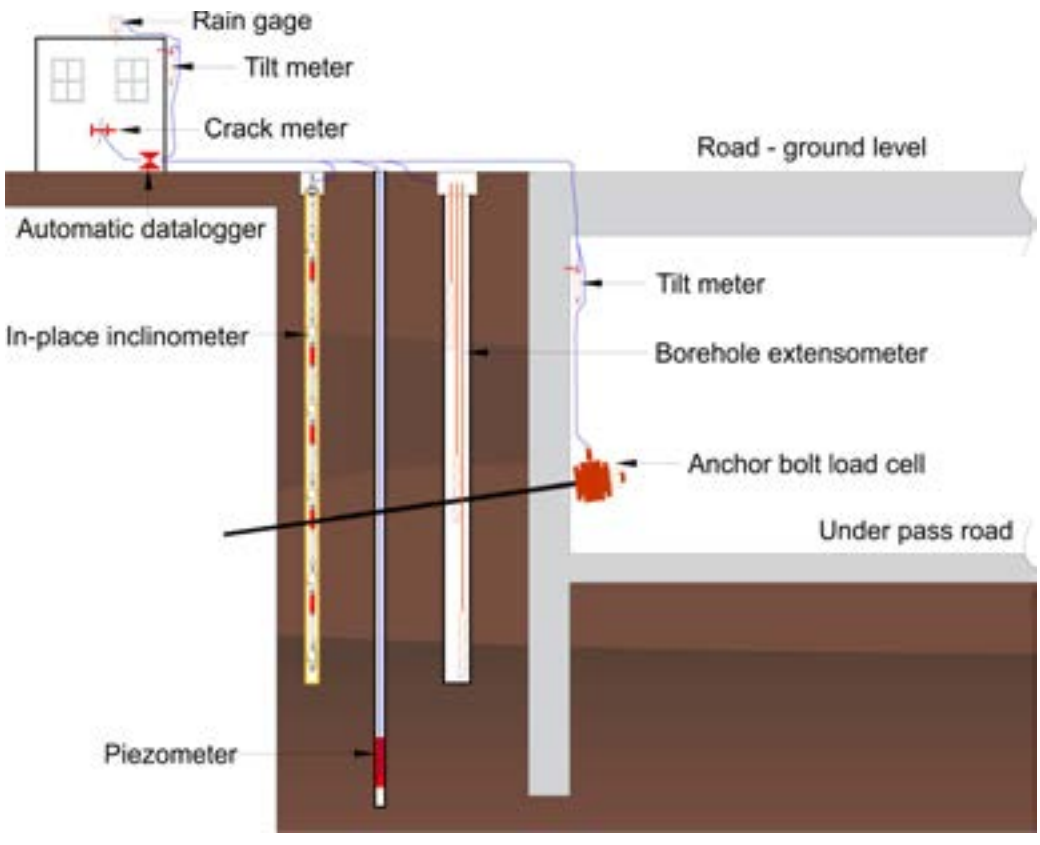
- Encardio-rite model EAN-52MV vertical in-place inclinometer system with several biaxial probes (with integral SDI-12 protocol) mounted vertically in a borehole to monitor sub-surface lateral movements around the structure.

- Encardio-rite model ERG-200 tipping bucket rain gage (with ESGI-10 SDI-12 interface).

- Encardio-rite model ESDL-30 data logger for the above mentioned sensors, with integral GSM/GPRS modem for storing and transmitting data to a server. For details refer to data sheet 1216-15 datalogger for SDI-12 interface sensors

- Encardio-rite online web data monitoring service (WDMS) that provides data online (with alarms) to authorised users at different locations, on their computer/laptops. More details are given in section 3.





Typical instrumentation scheme for deep excavation

NOTE:
Data retrieval from datalogger is also possible by directly downloading it on a laptop. Collapse of a building or bridge is often preceded by change in tilt of affected areas. The above instrumentation is a standardized low cost system effectively used to online monitor several type of structures to give timely warning on impending danger. The purpose is to assist and inform owner/designer/contractor/architect about continued performance of structures under gradual or sudden changes to their state.

The main factors affecting the performance is degradation of structure with age, undue settlement/tilt due to soil conditions or nearby construction activity, vibrations due to traffic, ground water level, atmospheric conditions and movement of slopes in hilly areas etc. This may be reflected in abnormal changes in tilt and settlement values.

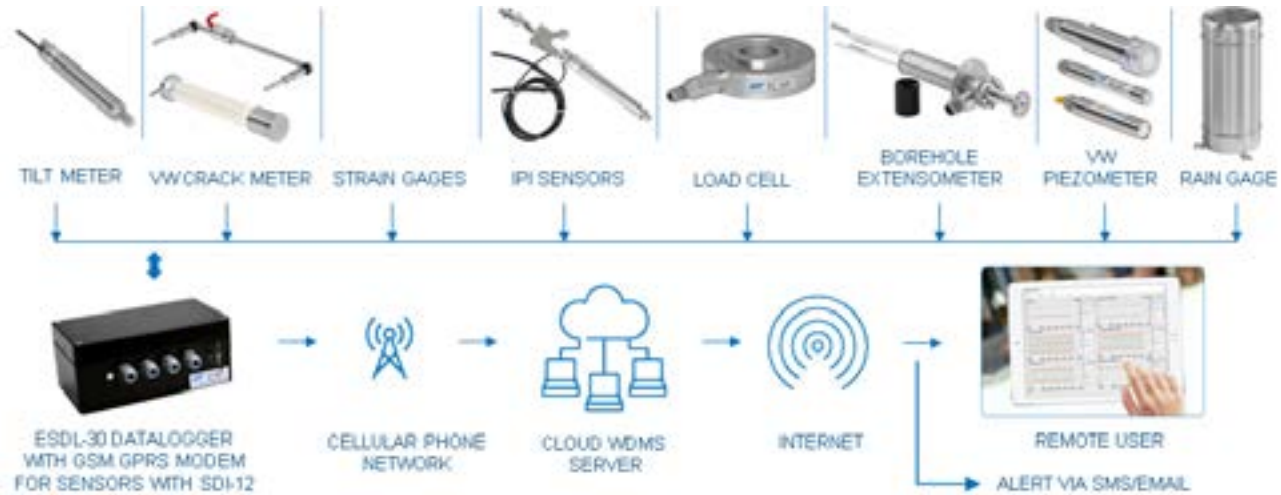
Data is available online with alarms through Encardio-rite Web Monitoring Services. For buildings and structures built on a hill or a mountain, this is a good low cost service for monitoring their stability with time. It may give forewarning of ground movement during rainfalls.

2.1 Public Cloud Based Web Data Monitoring Service (WDMS)

The heart of the online structural monitoring instrumentation system is a Public Cloud Based Web Data Monitoring Service offered by Encardio-rite for retrieving data from the ESDL-30 SDI-12 data logger, archiving the data in a SQL database, processing the data and presenting the processed data in tabular and most suitable graphical forms for easy interpretation of the logged data. The tables and graphs related to any site or sites can be accessed by authorized personnel who can login to their site using the supplied login ID and access password from anywhere in the world over the internet.

No special software is needed for accessing the user sites as the information can be viewed using most standard and popular web browsers like Microsoft Internet Explorer, Mozilla Firefox, Google Chrome etc.

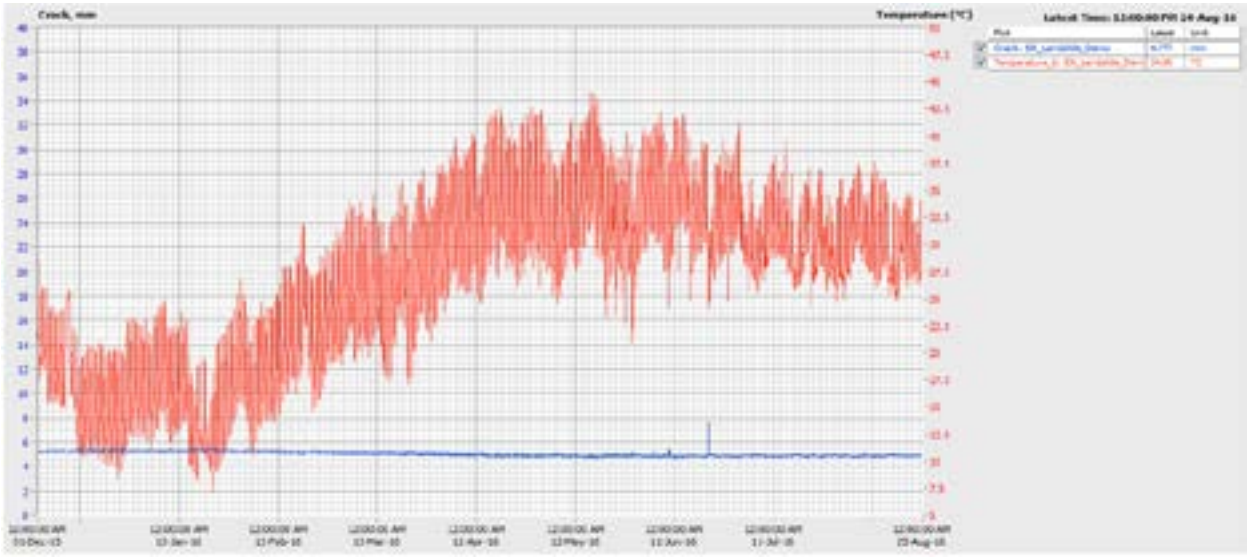
Data from Encardio-rite cloud based web monitoring service can be accessed from just about any type of device that supports a standard web browser like a desktop or laptop PC, Tablet, smart phone or most other mobile computing devices.
Depending on importance, soil conditions, architectural designs, risks and hazards, structures may have different monitoring programmes. The monitoring programme at times can also be mandated by law.



Typical schematic for instrumentation, datalogger and data transmission

A graphic like a map, ground plan or a photograph is put on the opening screen marked with position of installed sensor/ sensors represented as square dots.

As soon as the mouse pointer is brought over any sensor location the corresponding sensor details like sensor identification Tag, last recorded sensor reading, and the values of the programmed alert levels pop up in a box. If any one of the alarm level is exceeded the sensor location turns to a red dot. Clicking the pop up table with the mouse brings up an associated data window where the sensor data can be seen either as a table or as a graph.



Site administrators can set two alarm limits which are generally considered as “alert level” and “evacuate level”. Other users can only view the data and alarm status but cannot make any changes.

The WDMS can also be programmed to send SMS alert messages or e-mail to selected users as soon as any sensor data crosses its predefined alarm levels, either while going above or going below the alarm level. It can also be programmed to send the health status of the system to selected users.

The web browser interface is very simple to use and intuitive. Any user who is only interested in viewing the data and reports will take just a few minutes to get familiar with the operation of the system.

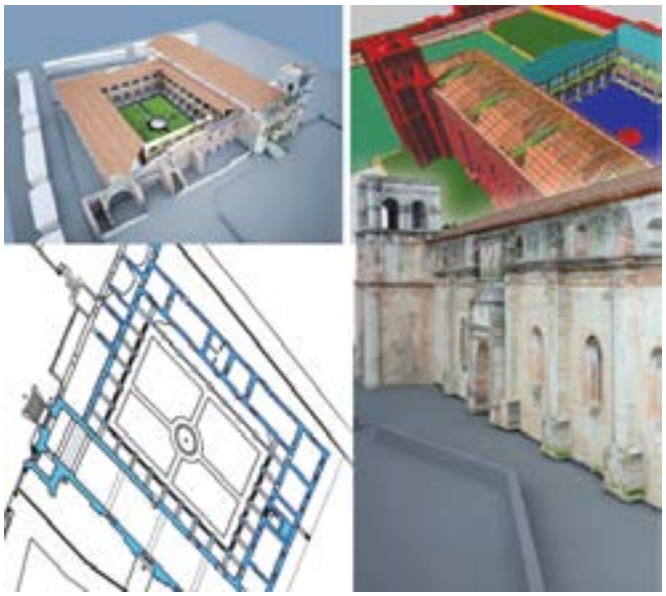
Encardio-rite cloud services work on a rental model. User has to pay a small setup fee for first time and then a monthly rental has to be paid for accessing the data over the cloud as long as required.
NOTE: Data retrieval is also possible by directly downloading it on a laptop

3 STRUCTURAL SURVEY

Encardio-rite group of companies and Moniterra group of affiliated companies are associated together to offer a complete solution for safety monitoring. With our combined experience in online structural surveys and monitoring, we are today one of the most formidable companies in this field.

3.1 Laser scanning/BIM

Laser scanning is an advance method of surveying and conducting geometric documentation of buildings, architectural and archaeological monuments, engineering projects (such as tunnels, bridges, dams, etc.) or other construction works and objects which require a high degree of analysis, are difficult to reach or gain access to, or are not to be touched.



It is based on exceptionally dense mapping of 3D coordinates of the points on the surface that is to be surveyed, taken at speeds ranging from a few thousand up to a million points per second. Depending on the object (size, shape, desired accuracy), laser scanning may be airborne or terrestrial, static or mobile, autonomous or in combination with other standard topographic methods.

Completion of the fieldwork results in a geo-referenced point cloud which, due to its great density and its ability to bear information on the reflectivity and/or the color of each point, comes close to the term, “virtual reality”.

Depending on the case and on the user’s needs, horizontal, vertical or diagonal sections, aspects, images, videos, orthophotographes, surface expansions, interval curves, 3D models, determination of distortion as well as a number of other analysis derived from the scanner’s operations in the non-visible spectrum, can be produced.

To summarize, the results of laser scanning gives us:

- Surveying of current state and of «as constructed» state
- Virtual reality creations; Virtual tour videos
- Geometric documentation of structure
- Quantitative calculation
- Inspection of free passage space – determination of bottlenecks
- Creation of 2D & 3D products (sections, facets, 3D models, etc.)
- Identification of deformations – discrepancies
- Few application areas where laser scanning is an efficient survey method to reduce costs giving a fast, reliable and inexpensive 3D survey:
- Multistory and historical buildings; Foundations
- Dams, Tunnels, Bridges and overpasses, Rail/Road Projects; Walls, Pylons, etc.
- Landslides and Sloping ; Earthquake-prone regions

3.2 Aerial Mapping using Unmanned Aerial Vehicles (UAV/Drone)

Inspection of huge and complex structures like buildings, monuments, engineering projects (such as tunnels, bridges, dams, etc.) requires high degree of analysis but at times are difficult to reach or gain access to. Use of Unmanned Aerial Vehicles (UAV)/Drones is best suited for such applications.

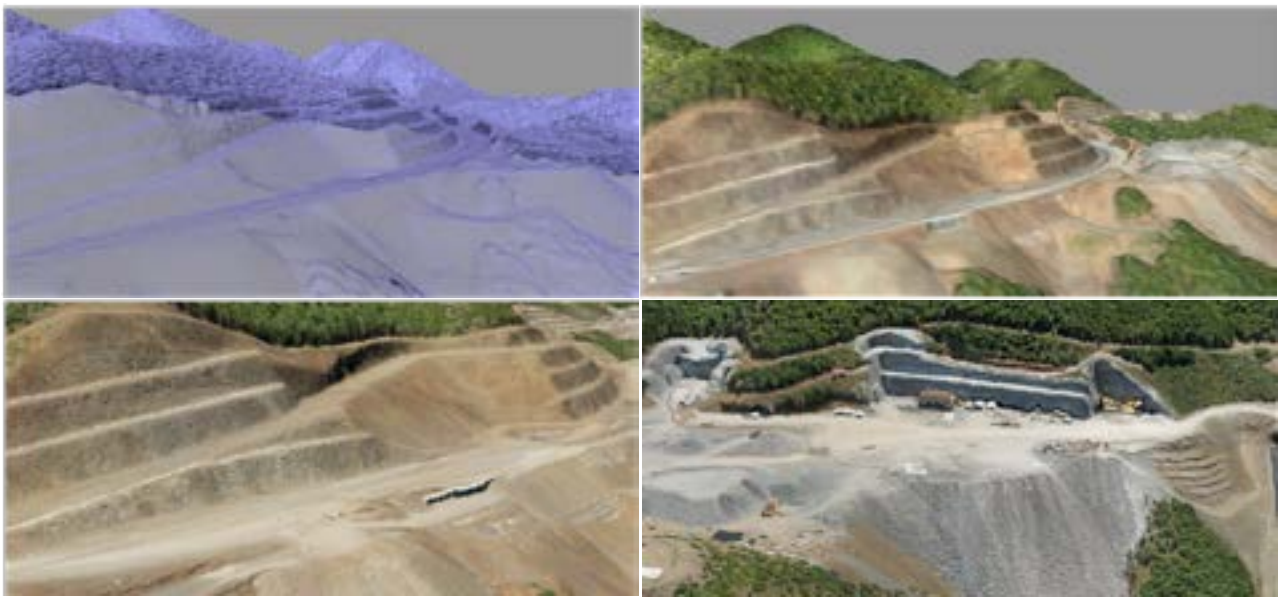
UAVs/Drones are unmanned and remotely-piloted aircrafts that follow a pre-programmed path for takeoff, flight and landing. These aircrafts are equipped with HD/IR/Thermal cameras that compute aerial images and videos over a defined area at specified height.

Using UAVs/drones to video, model and scan for cracks, erosion, corrosion and defects in areas that would otherwise require the inspector to climb, repel, hang from a rope/harness or erect scaffolding is obviously a safer, faster and smarter choice.

Large sites and engineering projects necessitates expensive ground based surveys or aerial photogrammetry. Also, as the development occurs, managers have difficulty maintaining a true picture of the site. With UAV-based mapping at regular intervals, this information gap can be closed.

Results from UAV/drone are in following forms:

- Photos & Orthophotos
- Mesh 3D Models & Texture 3D Models
- Drawings
- Videos – Presentations
- Contour maps
- Slope maps
- Area - Volumetric calculations



3.3 Automatic deformation monitoring system (ATS)

The Real Time 3D deformation monitoring system is a systematic tracking of any alteration that may take place in the shape or dimension of structure as a result of stress, load, aging etc.

It also monitors the lateral and vertical movement of existing structure which is affected during construction/excavation period.

The deformation monitoring system consists of high accuracy automatic total stations (ATS) that have the ability of auto target recognition (without any human interference).

Each ATS has a dedicated control box that includes a computer running special software. This control box manages the total station and schedules the frequency of the measurements, the addition or subtraction of monitor benchmarks, the filters of acceptance or repetition of each measurement, the atmospheric corrections in distance measurements, the calculation and repositioning of the total station etc.

The whole system can be controlled/re-configured remotely after installation at site. The on-site system transmits the collected raw data to a remote server/computer via GPRS/GPS. Raw data is processed into meaningful results by specialised software. The system has the facility of alert notifications through sms, email to authorized team for any result exceeding present alarm and critical levels.



The system provides an accurate, continuous, real time data, eliminating any human error/delay in manual data. The raw data is processed, analyzed and the result is majorly used for predictive maintenance, alarming for safety. Few applications are:

- Multistory and historical buildings; Foundations
- Dams, Tunnels, Bridges and overpasses, Roads
- Landslides and Sloping ; Earthquake-prone regions

4 REFERENCE GUIDELINES FOR BUILDING DAMAGE CLASSIFICATION

Classification of building damage as summarized from **Burland et al, 1977 by Boscardin and Cording 1989.**

Building damage classification	Approximate. equivalent ground settlements and slopes (after Rankin 1988)			
Risk category	Description of degree of damage	Approximate. crack width (mm)/number of cracks	Max. slope of ground	Max settlement of building (mm)
1	Negligible	0.1 to 1	<1:500	<10
2	Slight	1 to 5	1:500 to 1:200	10 to 50
3	Moderate	5 to 15/no. of cracks > 3	1:200 to 1:50	50 to 75
4	Severe	15 to 25/also on no. of cracks	1:200 to 1:50	>75
5	Very severe	> 25 /also on number of cracks	>1:50	>75

5 CONCLUSION

The data observed from the structural instrumentation described above plays a vital role in safeguarding existing buildings and other structures, providing verification of design assumptions, manage the construction in a safe and controlled manner and monitoring long term behaviour.

The instruments used and the manpower deployed for installation, monitoring and maintenance of instruments have therefore to be top quality and reliable. Encardio-rite Group of Companies with an experience in manufacturing and monitoring of almost half a century, are one of the best service provider in the field.

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