Structure Inspection using UAVs

AUTHORS

D K Kumud *completed his Executive training in 1996 and joined NTPC Unchahar in Erection of 210 MW units. He has worked in Erection, Commissioning, and Maintenance of 210 MW units. Presently he is working in maintenance and erection of Coal Handling Plant at NTPC Korba. He is also IPMA Level 'D' certified project manager.*

A K Behera *graduated from UCE Burla,Sambalpur in Electrical Engineering in year 1992. He joined NTPC in 1996 and was posted at NTPC Talcher-Kaniha and worked in MGR. Presently he is working in Coal Handling Plant at NTPC Korba.*

Introduction:

A structural element can be subjected to various kinds of loading conditions, including fluctuating stress/strain, fluctuating temperature (thermal fatigue), or any of these in a corrosive environment or at elevated temperatures. Most service failures occur as a result of fluctuating tensile stresses

As structures are aging, the assessment of buildings and industrial structures is becoming increasingly important. Also a conservative design does not result in a significant increase in structural cost while a conservative assessment may result in unnecessary and costly repairs or replacement.

Structural assessment can be initiated, when there has been a change in resistance. Such as structural deterioration due to time-depending processes (e.g. corrosion, fatigue) or structural damage by accidental actions. Also when there will be a change in loading (e.g. increased load) or an extension of the design working life. Assessment can also be carried out to analyze the current structural reliability (e.g. for environmental hazards like earthquake or extreme winds and/or waves).

Within the power industry, the aging of plant structures, systems, and components has become the subject of significant research in the last few years. This interest is prompted by the need to quantify the effects of aging in terms of potential loss of component integrity or function and to support current or future condition assessments of critical components. Since certain structures play a vital role in the safe operation of power plants, guidelines and criteria for use in evaluating the remaining integrity (residual life) of each structure are needed.

This is to ensure that no age-related degradation alters the performance of components, systems, and structures significant to safety and reliability.

Structural condition assessment:

Structural Component Assessment has the following objectives:

(1) Development of a systematic methodology for quantitatively assessing the presence, magnitude, and significance of any environmental stressors or aging factors which could impact the durability of safety-related vital components in power plants; and

(2) Providing recommended in-service inspection or sampling procedures which can be utilized to develop the required data both for evaluating the current structural condition as well as trending the performance of these components for use in continued service assessments. One of the activities under this task, "In-service Inspection Techniques," has the objective of reviewing and assessing non destructive and destructive evaluation, sampling, and structural integrity testing techniques, which have application to the evaluation of safety-related vital components in power plants.

Actual in-service inspection results are to be factored into the review and assessment. In meeting the objective of this assessment, potential environmental stressors and aging factors to which power plant structures may be subjected are identified and their manifestations noted.

Appropriate nondestructive and destructive testing techniques that can be used to assess the severity of each of these degradation factors are identified and reviewed. Testing methodologies being used to perform condition assessments of critical components are also reviewed and assessed.

Visual assessment of critical structure is done primarily to assess the condition of structure and to ascertain the extent to which the testing or the study to be carried out in getting the residual life. The preliminary visual inspection if done for the first time may involve the thorough inspection so that area where attention is needed is clearly identified. In subsequent visual inspection the identified area may only be focused and details assessment using different technique can be applied.

In Thermal power plant, mostly the tall structure and structures which are subjected to adverse condition are found to be deteriorating very fast. If the plant life is already at the fag end, the equipment and machinery are replaced or renovated and modernized, but steel and concrete structures are difficult to repair or replace. Moreover the preliminary assessment involves heavy cost which forms the basis of detail investigation by some expert group which in turn recommend for repair or replacement.

UAV:

An Unmanned Aerial Vehicle (UAV) is defined by the FAA as an aircraft flown with no pilot on board. UAVs are sometimes referred to as drones and the name can be used interchangeably. Unmanned Aerial System (UAS) is also a term that is commonly used. The vehicle is controlled either autonomously or with the use of a remote control by a pilot from the ground and can carry a wide range of imaging technologies including still, video and infrared sensors. UAVs are an emerging technology with many potential applications in the civil engineering field. One application that is routinely mentioned is the area of bridge inspection due to the logistical challenges to efficiently and effectively visually inspect a wide variety of structure types in challenging locations

The use of UAV (Unmanned Aerial Vehicles) or DRONE may be a better option for preliminary visual assessment of tall structures or high rise structures like Chimneys, Conveyor gallery and structure etc. whereas making scaffolding is a costly option.

Case Studies:

NTPC Korba has recently explored the possibility of carrying out the visual inspection of Chimney and structure of Conveyor galleries where the normal approach is not available. The results are encouraging and satisfying.

Study-1: Carrying out conveyor galleries and structure inspection using drones

Drone doing inspection of bottom of gallery

Drone used for survey

The advantages of the structure inspection using drone are:

- It is completely safe.
- It is quick and reliable.
- The repeatability is always ensured. In case of inspection using scaffolding the repeatability will involve heavy cost and also time is required.
- The cost incurred is too less, results are quick so the taking decision for any repair/replacement is quick.
- The real time data generation analysis by experts is also possible.
- The Drones enabled with GPS may be pre-programmed and the critical area may be intensely examined.
- Re-examination of area of interest may be done again and again.
- The cost may be optimized by erecting platforms or scaffoldings in area where intense inspection is required. This saves cost and time.

Conveyor structure bottom view

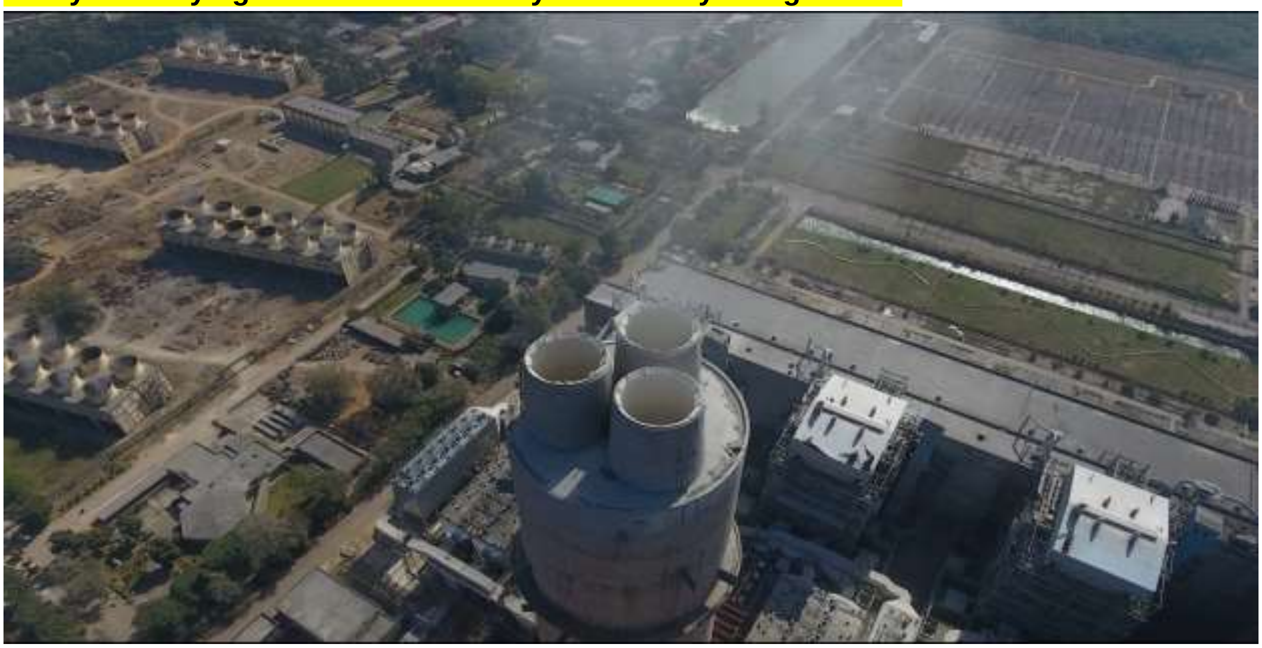
The trial was taken to explore the possibility of whether the difficult location of conveyor gallery which is lower part where no approach is readily available and separate scaffolding is to be made and it to be used by experts to check the structure.

The photograph of Conveyor structure bottom view shown here is of the picture taken by Drone fitted with 4K camera. This inspection was only on trial basis, and the results are encouraging. The camera quality and exact positioning can be done and appropriate zoom may be done to enlarge the view hence the decision on assessed portion can be taken. Moreover on the day of trial the Sunlight was not proper, but when we will do the actual assessment from decision point of view the extra lights can be focused on the part which we want to explore.

The main disadvantage of the using drone is that if the defect is identified than separate platform or scaffolding is required to attend the same, whereas in case of manual inspection the repair can be done along with the inspection. However the tradeoff is required between Drone inspection in manual inspection.

The main objective of this study was to reduce the inspection and measurement time.Also to carry out the inspection of structures of difficult locations without huge investment and cumbersome process of erecting scaffoldings as well as reducing time.

Study-2: Carrying out condition survey of Chimney using Drone.

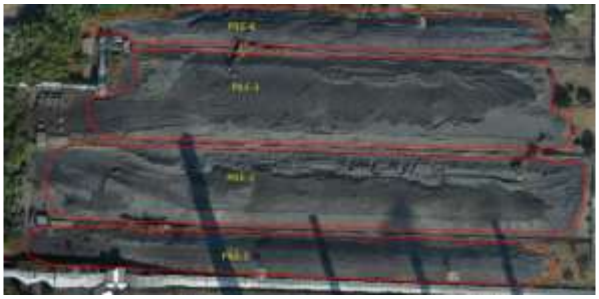


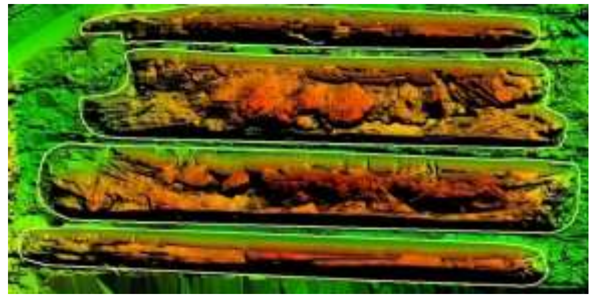
NTPC Korba Stage-I Chimney Top

In tall structures like chimney where top portion is to be regularly inspected for any damage due to temperature can be easily accessed and preventive and corrective action can be taken.

Study-3: Coal Stock Survey using Drone

Photographs of coal stock survey through drones





Piles Ortho View *Piles DSM View*

The Drone survey for coal stock carried out to ascertain actual stock in coal stack yard. The Drone survey was validated with the manual survey usually carried out. The error % was …… the Drone survey was carried out in just 15 minutes against the usual manual survey carried out in two days.

Use of UAV for structure assessment in other countries:

Use of drone for visual assessment of structures: Demo project

The overall goal of the UAV Bridge Inspection Demonstration Project was to study the effectiveness of utilizing UAV technology as it could apply to bridge safety inspections. The project team investigated the technology on four bridges located throughout Minnesota. The project team evaluated the UAVs effectiveness as it could apply to bridge inspections based on UAV field results. Various UAV capabilities were utilized to evaluate current technologies as they relate to use in bridge inspections. This study details the advantages and challenges of potentially using UAVs to aid in bridge inspection, an analysis of current and future UAV technologies as they relate to bridge inspection, and an analysis describing how current and future technologies adhere to the National Bridge Inspection Standards.

Difficult Bearing Location **Pier Cap Concrete Structure**

Bridge Pin Details (Close view with UAV)

Courtesy: Bridge Inspection Demonstration Project Report 2015, Minnesota Department of Transportation

Legal Requirements of Drone Operation in India:

The requirements for operation as per draft Guidelines for obtaining Unique Identification Number (UIN) & Operation of Civil Unmanned Aircraft System (UAS)

1. *Irrespective of weight category, the UAS operator shall intimate Local Administration, ATS unit (for operations at or above 200ft AGL in uncontrolled airspace), BCAS, Aerodrome operator (if applicable) before commencement and after termination of operation. In the event of cancellation of UA operations, the operator shall notify the same to all appropriate authorities as soon as possible.*
2. *The operator shall refer to Aeronautical Information Publication (AIP) and active NOTAM regarding details of notified prohibited, restricted and danger areas (airspace) including TRA and TSA. The operation shall be restricted to areas outside the boundaries (lateral and vertical) of above mentioned areas in the uncontrolled airspace.*
3. *The operator shall carry out safety assessment of the UA operations including the launch/ recovery sites. The UAS operation site (including emergency operation zone and any safety zone for the operations of the UAS) shall be under the operator's full control.*
4. *Privacy and Protection of Personnel/ property/ data shall be given due importance.*
5. *UA shall be operated in accordance with the rules governing the flights of manned aircraft as specified in CAR Section 9, Series C, Part I (Rules of the Air). 10.6. UA should be able to comply with regulations applicable to the class of airspace within which they intend to operate as specified in CAR Section 9, Series E, Part I (Air Traffic Services).*
6. *For operations at or above 200ft AGL in uncontrolled airspace, the UA operator shall file a flight plan and obtain necessary clearances with concerned ATS unit and ADC.*
7. *The flight plan shall contain the following information, but not limited to the following:*

   a) Description of the intended operation (to include type of operation or purpose), flight rules, visual line-of-sight operation, date of intended flight(s), point of departure, destination, cruising speed(s), cruising level(s), route to be followed, duration/frequency of flight.

b) Performance characteristics of UA, including operating speed, maximum climb rate, maximum rate of descent, maximum turn rate, maximum range and endurance. c) Number and location of remote pilot stations. d) Fixed Payload information/description. e) Proof of adequate insurance/liability coverage. f) Contact number of the remote pilot and/ or RPS in field 18 of the Flight Plan.

8. *The UAV shall enter the controlled airspace only with the prior approval of the ANS provider, which will be in the form of an airways clearance. The SOP shall contain take-off/landing procedure, collision avoidance procedure, noise abatement, flight plan filing, local airspace restriction, right-of-way rules, communications requirements, UA emergency procedures, pre co-ordination and procedures necessary to safely recover UA through controlled airspace in case UA system failure precludes the ability to remain outside controlled airspace, etc. AIP Supplement of AAI may be referred for flying outside the control airspace.*
9. *Prior to the operations of UA, the operating personnel shall be in coordination with the appropriate ATS Authority, and Local police station probably through VHF/ landline/ two mobile phones with independent service providers.*
10. *Remote pilots should prefix RPA call sings with the word UNMANNED during voice communications between ATC and the remote pilot station.*
11. *The operator shall ensure that the UA is flown within 500m Visual Line of Sight (VLOS) during the entire period of the flight. (Applicable for micro and mini UA)*
12. *International operations of civil UAS (flying across the territory) and/or over water shall be strictly prohibited. The UA shall not be flown over the entire air space over the territory of Delhi (30km radius from Rashtrapati Bhavan) and areas falling within 50 km from the international borders. Also, UA shall not be flown over other sensitive locations viz. nuclear stations, military facilities and strategic locations.*
13. *UA flight shall be conducted as per the manufacture's approved UAFM available with the remote pilot within the Remote Pilot Station (RPS).*
14. *UA shall be operated (as VFR flight only) when the following meteorological conditions exist:*

   a) During daylight with Visual Meteorological Conditions (VMC) having ground visibility of 5 km.
   b) Surface winds of not more than 20 knots (measured using hand held anemometer at site).
   c) Cloud base not lower than the approved altitude of operations.

15. *10.16 The UAS operator shall not launch the UA when rain/ thunderstorm warning is in force.*
16. *The UAS operator shall have adequate means to ensure that the actual altitude flown is accurate.*
17. *The operator shall be responsible for ensuring that the UAV is operated safely and remains clear of air traffic including other UAs and obstructions except where operation in close proximity of obstacles has been authorized on the operator's UAOP.*
18. *The take-off and landing area should be properly segregated from public access.*

19. *Designated "safe areas" should be established by the UAS operator for emergency UA holding and flight terminations.*
20. *UA shall not discharge or drop substances unless specially cleared and mentioned in UAOP. UA shall not carry any explosives/ dangerous goods, animals/ human payload etc.*
21. *Operator shall ensure that no Radio Frequency Interference (RFI) is caused to air traffic operations and air navigation equipment.*
22. *The UA shall have following components/ equipment:*

    a) Identification plate and/ or RF ID;
    b) SIM card slot for an app based tracking (Mandatory for Micro & Mini UA);
    c) SSR transponder (Mode 'C' or 'S') or ADS-B option (Mandatory for Small & Large UA);
    d) GPS/ INS (with option to GPS tracking and Geo Fencing);
    e) Detect and avoid capability (if required, operator shall engage an RPA observer)
    f) Return Home option (mandatory in the event of failure)

23. *For operation of large UA, it is recommended that reporting of UA position by the ground control station in ICAO standard ATFM format to ATS/ AD agencies.*

Take away:

We can conclude that the pilot project carried out by NTPC, the use of UAV or Drone is very effective in assessing the health of tall structures. The cost and time saving can be traded off with the results. The intensive inspection can be planned without inspecting whole structure manually. With advancement of technology the judgment will be more accurate, however the legal compliance of use of Drone is in nascent stage and more clarity on the subject is needed for widespread use in power plants.

The coal survey with the help of Drone will be a landmark activity. Presently using the basic technique of survey of coal piles may not be too effective when the frequent survey has to be carried out to ascertain the actual coal stock.

The tall structures like Chimney inspection and top liners can be easily done in cost effective manner. The advantage of Drone is that it can take picture in running condition of flue gas and with a suitable distance. The different angle can be used for assessment and conclusion can be easily drawn.

NTPC can replicate this assessment in other projects also and leverage this technology with apparent potential cost saving and timely detection and assessment of support structures and tall structures like Chimneys and NDCT. The Drone can be made available at Corporate level with NETRA where expertise is already available for assessment of structure which will be utilized for assessing the condition of structures of plant like NTPC Korba.