INTRODUCTION

THEORY

SYSTEM & ACCURACY

APPLICATIONS

CONCLUSIONS
INTRODUCTION

Our infrastructure is expanding and existing infrastructure is aging
Determine the behavior of the structure under various loads and environmental effects
Know the condition of the structure before it is too late
   Inspection- non-destructive testing
   Repair or replacement

Pre-stressing is a key element to the performance and durability of the structures where they are installed

Anchor Force
   During construction
   Long-term monitoring
   Periodic, continuous, remote

INTRODUCTION Cont'd

Anchor embedded or external

Anchor either of strand or high strength bar

Strand/bar can be of bare, coated or grouted

Various methods to measure the anchor force

Most are cumbersome and accuracy differs

DSI involved in development, testing and utilization of DYNA Force to measure the force in anchors
THEORY

DYNA Force sensors are manufactured based on the magneto-elastic properties of ferrous material.

FARADAY'S LAW: Change in magnetic environment of a coil of wire will cause a voltage to be induced in the coil

\[ \mathcal{E} = -\frac{d}{dt} (\phi_B) \]

\[ \mathcal{E} = \text{ELECTROMOTIVE FORCE} \]

\[ \phi_B = \text{MAGNETIC FLUX} \]

Sensor is composed of a primary coil and a secondary coil

By passing current through primary coil, ferromagnetic material is magnetized

Sensing coil picks up induced electromotive force that is proportional to change rate of applied magnetic flux and relative permeability

As permeability of core changes, output voltage changes

Output voltage is calibrated to measure force
SYSTEMS

DYNA Force System consists of mainly sensor and readout unit
The force can be measured by:
- Manual reading
- Local data storage
- Remote access

<table>
<thead>
<tr>
<th>DF Sensor</th>
<th>Readout Unit</th>
<th>Multiplexer</th>
</tr>
</thead>
</table>

7 DF Sensors for Force Monitoring

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SYSTEMS- Cont’d

Table: DYNA Force Dimensions

<table>
<thead>
<tr>
<th>Strand Size</th>
<th>Strand Grade</th>
<th>Sensor Dimensions [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[in]</td>
<td>[KSI]</td>
<td>ID</td>
</tr>
<tr>
<td>0.5” - 0.62”</td>
<td>270</td>
<td>0.79</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THREADBAR Size</th>
<th>Bar Grade</th>
<th>Sensor Dimensions [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[in]</td>
<td>[KSI]</td>
<td>ID</td>
</tr>
<tr>
<td>#7 - #11</td>
<td>75-97</td>
<td>1.69</td>
</tr>
<tr>
<td>#14</td>
<td>75-97</td>
<td>2.09</td>
</tr>
<tr>
<td>#18 / #20</td>
<td>75-97</td>
<td>2.87</td>
</tr>
<tr>
<td>#24</td>
<td>75-97</td>
<td>3.35</td>
</tr>
<tr>
<td>1” - 1-3/8”</td>
<td>150</td>
<td>1.69</td>
</tr>
<tr>
<td>1-3/4”</td>
<td>150</td>
<td>2.09</td>
</tr>
<tr>
<td>2-1/2”</td>
<td>150</td>
<td>2.87</td>
</tr>
<tr>
<td>3”</td>
<td>150</td>
<td>3.35</td>
</tr>
</tbody>
</table>

DYNA Force over the x-section of the anchor is custom made
and dimensions will be provided upon request
Due to the diversity of the magnetic property of steel, calibration is done for each type of steel allowing the sensors to perform at their highest accuracy.

Three sensors were used in each of three 59-0.6” strand anchors. Sensors were consistently more accurate than load cells when compared to the actual jacking force.
MEASURING PROCEDURE

Sensors supplied are pre calibrated at DSI facility

Install over the strand/bar during construction

Attach portable readout unit to wire leads from DYNA Force

Take a zero reading before applying any force

Apply anchor force

Measure the force in anchor anytime

DYNA FORCE- usage in the World
DYNA FORCE usage in USA & Canada

DYNA FORCE Sensor Usage over the past years

DYNA Force Systems have been used over sixty projects

- Dams
- Tie-Back Anchors
- Tie-Down Anchors
- Cable Stay
- Bridges
- Repair of Structures

- Federal, State & Private Projects
- USACE Projects
- FERC Projects
- Caltrans Projects
- USS Battleship Projects
DYNA FORCE- Sensor installed on Threadbar Anchor
Installation on the un-bonded length

DYNA FORCE- Sensor installed on Strand Anchor
Installation on the unbonded length
APPLICATION- Patton Creek Shopping Mall, Birmingham, AL

Original 1700 ft of crib wall of up to 50 ft tall showed cracking and the wall was moving. Retrofit was done with 345 permanent 9-0.6" strand anchors. DYNA Force sensors were placed at 8 anchors.

Before adding new road

After adding new road
APPLICATION- Byllesby Dam, MN
Eight sensors were installed to monitor forces in 1-3/4” DCP Anchors.

APPLICATION- Sellwood Bridge Abutment, Oregon
56 DYNA Force sensors were supplied to monitor the slope stability in front of the bridge abutment. Automated readout units were installed to record the force readings at every 4 hours.
2 Permanent Retaining Walls for Road Widening
Soldier Beam and Lagging System with up to 5 rows of tiebacks
470ea 4 thru 8-0.6” DCP Strand Anchors

APPLICATION - Retaining Wall - Rt 405, CA

48 DYNA Force sensors were installed on tie back anchors to monitor the performance of the retaining wall. Automated readout units were installed to record the force at every 4 hrs.
DYNA FORCE – Interstate 405 / Sepulveda Blvd.

Readout Unit
16 Channel Multiplexer
4 Channel Multiplexer
NEMA4 Enclosure
Modem
110V Power
Controller
Cables from Sensors

APPLICATION- Project in LA

18ea DCP Strand anchors to prevent from landslide.
14 Sensors (7/anchor) installed to monitor the forces in the anchors in un-bonded and bonded length of the anchors. Data is taken every 15 days and compared with the target value.
 APPLICATION- Project in LA

Sensors in bonded and un-bonded length provide valuable data to the engineer.

DYNA FORCE – Cable Routing

DYNA Force cables
• exit Corrugated Sheathing of the Anchor
• Get routed through the Concrete Pad
DYNA FORCE: For Compression

1-1/4" & 1-3/4" Gr. 150 Bar
#20 Gr. 80 Bar
#20 Gr. 80 Threadbar
Yield load = 393 kips, Applied load = 300 kips
Load kept at constant for over a week
Sensor and load cell readings were within 1%

DYNA FORCE: Field application for compression

#14 Gr. 80 Threadbar in drilled shaft of I-29 @ Mosquito Creek. Council Bluffs, IA
DYNA FORCE: For Compression

Setting up of cage with DYNA Force sensors in drilled hole

Completion of concrete pour of drilled shaft with DYNA Force sensors

CONCLUSIONS

DYNA Force sensors can be used for:
bare, epoxy-coated, galvanized and greased-sheathed steel in bonded, un-bonded, grouted or un-grouted length of the anchor.

Eliminates any lift-offs & friction tests.

Reduce the pocket depth since no load cell is required.

Portable read-out unit.

Reading in seconds by a trained person any time.

Owner can regularly monitor forces in anchor even from remote access.
CONCLUSIONS- Cont’d

Durability

DYNA Force system is robust
Requires no maintenance & has no moving parts
Similar service life to that of the structure

The accuracy of the force measurement is normally within 1.5% for strand and within 3% for bar for preinstalled DF sensors.