# EFFECT OF DEMOLITION ON REMAINING PART OF CONCRETE BRIDGE
# NUMERICAL ANALYSIS VS. EXPERIMENTAL RESULTS

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## The experimental part

This part of the research project required the installation of numerous strain gages on the concrete bridge at different locations, where demolition will take place. The deck of the bridge will be sawed at 8′-0″ (2.40 m) intervals. The concrete walls, backing the curbs will be demolished first, using the Hoe-Ram of 4″ (0.10m) diameter. After that the deck will be stripped from the pavement, then demolished, using 325 Caterpillar excavator, equipped with special bucket. Part of the abutments' walls will be demolished using the same Hoe-Ram. Therefore the logical places to install the strain gages were the deck, the concrete walls backing the curbs, the walls of the abutments and pier No.1. Those gages are supposed to measure the strains in the concrete, while the demolition is taking place in the nearby vicinity. Such measurements will help to determine how far from the point of demolition the concrete will reach the ultimate strength. The gages were installed to measure strains in two directions, vertical and transverse.

The installation of the strain gages was very tedious, because the installation process required precision. Added more to the difficulty, was the ruggedness of the terrain and its excessive steep. Furthermore, the demolition will not take place until May, 2000, which meant that the gages, which were installed in the fall had to be winterized to protect them from the rain, snow and rising level of water in the river during spring time. This meant protecting the gages by adding layers of butyl rubber, Teflon and aluminum adhesive tape to seal the gages against the weather, otherwise the gages may not work properly due to the change in their resistance. The gages are quarter bridge with 120.Ω resistance. A three wires connection was used because it reduces the effect of the imbalance of the lead wires internal resistance when they are very long. $R_{L1}$ and $R_{L3}$ balance each other because they are on the adjacent arms of the bridge. Furthermore, it reduces the effect of the temperature change on the internal resistance for the very long copper wires. Since the distance between the gages on the pier and the measuring devices could be more than 100.m., thus such reduction is very important to reduce the distortion in measuring strains.

The monitoring equipment is National Instrument equipment. It consists of SCXI-1000, which is a high-performance, multi-channel signal conditioning system for PC-based data acquisition. It consists of chassis, which houses signal conditioning modules for amplifying, multiplexing, filtering, isolating or digitizing signals. Transducer leads and signals are connected to shielded terminal blocks that plug directly onto the front of the signal conditioning modules. It has 4 blocks, each one has 16 channels. Thus it can record the measurements of 64 strain gages simultaneously. The whole system is used as an external data acquisition and control system that communicates with a lap top computer over the parallel port. The system is using Labview software.

The system is connected at the front end to the strain gages and at the other end to a lap top computer, which has a DAQ card (Data Acquisition Card). The equation, which measures the strain for the quarter-bridge is configured in the equipment. Since the demolition was postponed till May, 2000, therefore it was not possible to get actual data from the field, accordingly some simulated data were devised, by testing a Plexiglas plate fixed as a cantilever. Its length and width were 0.25m and 0.35m, and it had 6 mm thickness. Four gages were installed close to the fixed end of the plate, at equal intervals. The plate was subjected at the free end to a force of 44.5N at a location midway between gage 0 and gage 1. After conducting the simulated experiment shown in Fig.1, then examining the four gage readings shown in Table.1 and plotted in Fig.2. It was clear that gage 0 and gage 1 gave almost equal readings because they were at equidistant from the point of load application, while gage 2 gave less reading and gage 3 gave much less readings, because it is the farthest gage from the point of load application.

## The analytical approach and energy method application

A portion of the deck is considered with known boundary conditions and known point of application of the demolition tool. A concentrated unit load is considered acting at the point of demolition tool action. The slab deflection is calculated at different points of the mesh, using a finite element program such as ANSYS, stresses and strains are calculated at the points of the mesh. The total elastic and plastic energy of the deformed plate is calculated and multiplied by a magnification factor. The strain energy of the plate is made equal to the total applied energy of the demolition tool during a half cycle of the plate's natural frequency Masih and Hambertsumian [1], [2]. Such assumption considers that the plate keep absorbing the energy applied by the tool, while it is deflecting in the same direction of its vibration. For example if the natural frequency of the plate is $n_p$ cycles per second, the demolition tool energy is h N.m per stroke and the frequency of the tool is $n_t$ cycle/s, therefore the energy given by the tool to the plate during half a cycle is $h.n_t/2n_p$. Normally the tool has much higher frequency than the plate in order to be able to demolish the concrete plate, otherwise if the plate is so thick and rigid with very high frequency, then the demolition tool will not be effective. It will just chip off pieces at the point of application. Making the energy applied equal to the energy absorbed by the plate will give the value of the magnification factor k. Thus the actual value of the strain at the points of the mesh becomes known. Those points which have strains equal or higher than the concrete ultimate strain will be the damaged parts of the concrete deck, while those which have less strain than the ultimate are still safe. This way the distance from the load application to the safe points can be determined. The main source of error in this approach is the fact that the points, which are close to the point of load application will have elastic strains much higher than the ultimate strain of the concrete. The reason behind that is clear, because the solution is elastic analysis and those close areas will go through the plastic deformation rather than staying elastic, thus absorbing more energy than anticipated. In reality, this means that smaller area will be affected than what the analysis shows. However the strains could be adjusted later on to have those points not exceeding the ultimate strain. When the structure is analyzed as elastic then higher strain points will give higher elastic energy for a unit load than actually it is, which means the distance of the farthest damaged point is less than the actual. A correction factor can be devised by multiplying such distance with the ratio of the highest numerical strain to the ultimate strain.

## References

[1] Masih, R. and Hambertsumian, V., Predicting stability of lift slab structures by energy method, ASCE Journal of performance of Constructed Facilities, Aug 1997, Vol. II, No.3, PP 141-144.

[2] Masih, R. and Hambertsumian, V., Reliability of the energy method to predict stability of lift slab structures. ASCE Journal of Performance of Constructed Facilities.

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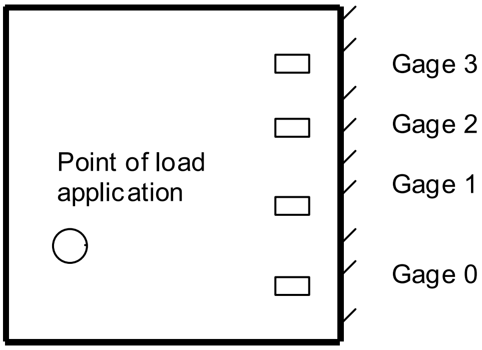

**Fig.1 A Plexiglas cantilever plat with 4 Strain gages placed at equidistant and a point load in an offset position**

Table.1 Showing the readings in Microstrains of four gages Placed on Plexiglas Plate

| Gage 0 | Gage 1 | Gage 2 | Gage 3 |
|---|---|---|---|
| 886.4918 | 937.8246 | 857.1613 | 710.5339 |
| 923.1575 | 923.1574 | 879.1589 | 739.8557 |
| 915.8242 | 923.1574 | 871.8263 | 732.525 |
| 886.4918 | 945.1582 | 864.4936 | 725.1945 |
| 908.491 | 901.1579 | 871.8263 | 732.525 |
| 937.8246 | 893.8246 | 857.1613 | 761.8486 |
| 952.492 | 901.1579 | 820.5003 | 783.8419 |
| 952.492 | 915.8242 | 827.8322 | 783.8419 |
| 923.1575 | 886.4918 | 871.8263 | 739.8557 |
| 937.8246 | 886.4918 | 835.1643 | 754.5177 |
| 901.1577 | 923.1574 | 857.1613 | 717.8641 |
| 893.8246 | 945.1582 | 857.1613 | 747.1869 |
| 886.4918 | 945.1582 | 842.4964 | 732.525 |
| 908.491 | 915.8242 | 871.8263 | 739.8557 |
| 930.491 | 893.8246 | 857.1613 | 754.5177 |
| 952.492 | 901.1579 | 849.8287 | 761.8486 |
| 930.491 | 901.1579 | 871.8263 | 732.525 |
| 937.8246 | 893.8246 | 842.4964 | 761.8486 |
| 937.8246 | 893.8246 | 849.8287 | 747.1869 |
| 923.1575 | 930.4911 | 820.5003 | 783.8419 |
| 923.1575 | 930.4911 | 791.1734 | 798.5053 |

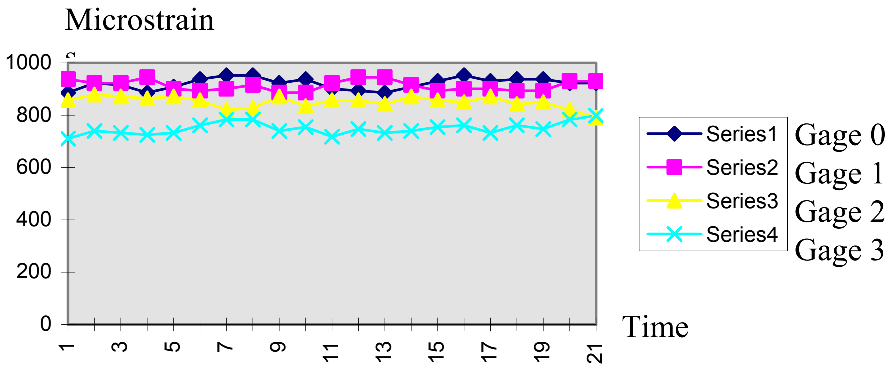

**Fig. 2 Graph of Four Strain Gage Readings in Microstrains vs. Time. The 44.5N load was placed between gage 0 and 1**