When considering the reuse of an existing substructure, it may not be clear how to determine if the new proposed loadings, which are often times larger than the existing, will be able to be carried by the existing foundation without excessive settlement of deflection. These existing foundations were often designed using service or allowable stress methods which make it difficult to determine the factored resistance available from these foundations which have successfully carried the current load demands for several years. While either the structural or geotechnical capacity limitations may prevent its reuse, the department has developed the following procedure to determine if the substructure and foundation can be reused. An “abbreviated analysis” should first be done to quickly determine if the reuse is acceptable or if a more “detailed analysis” is required

The abbreviated analysis first involves verifying that the substructure elements have an NBIS Condition Rating of 6 or greater and show no significant structural distress under existing load. If this is found to be adequate, when the proposed service dead load at the bearing seat is being increased less than 15% above the existing service dead loads, the foundation can be assumed to have adequate excess capacity to support the new loading. Lastly, there should be no significant reconfiguration of loads such as changes to bearing locations or substructure fixities. If any of these three conditions are not met, a detailed analysis will be necessary.

A detailed analysis involves structural capacity check of the existing substructure elements (caps, columns, stems, footings, etc.) and geotechnical check of the foundation elements (piling, shafts and spread footing).

Structural elements originally designed using the AASHTO ASD or LFD design codes require a capacity check using an HS-20 live load with an Illinois Modified Group-1 load combination per the AASHTO LFD Bridge Design Specifications shown below:

$$1.15 \times DL + 1.3 \times (1.67 \times LL)$$

As a minimum, the substructure elements shall also be investigated for the Standard Specifications, Division 1A, 500 year seismic hazard. Existing substructures originally designed using the LRFD design code may be evaluated as described above with the exception that HL-93 Live Loading shall be used.

Pile Foundations: When existing production pile driving data is available, the “as driven” pile resistance may be used rather than the plan design capacity. Existing piles often have greater geotechnical resistance than specified on the original plans due to various factors. The following table and the example calculation provide a method to calculate the potential increased pile capacity for existing structures constructed prior to January 2007. The increased pile capacity calculated using this table does not apply to structures constructed after this date.

Existing Pile Capacity Determination Table:

<table>
<tr><td>C_s</td><td>Existing Pile Capacity Source</td><td colspan="3">Existing Driving Records
(0% capacity increase)</td><td colspan="3">Existing Plans Pile Data
(10% capacity increase)</td></tr>
<tr><td>C_b</td><td>Low Capacity Formula Bias</td><td colspan="3">Pile Capacity > 40 tons
(0% capacity increase)</td><td colspan="3">Pile Capacity < 40 tons
(6% capacity increase)</td></tr>
<tr><td>H_e</td><td>Hammer Efficiency Correction</td><td colspan="2">Closed End Diesel, Drop or Unknown Hammer
(0% capacity increase)</td><td colspan="2">Open End Diesel Hammer
(4% capacity increase)</td><td colspan="2">Air-Steam Hammer
(8% capacity increase)</td></tr>
<tr><td>P_e</td><td>Pile Effect on Hammer Efficiency</td><td colspan="3">Precast Concrete or Timber Pile
(0% capacity increase)</td><td colspan="3">Metal Shell or Steel H-Pile
(4% capacity increase)</td></tr>
<tr><td>P_l</td><td>Pile Length Formula Conservatism</td><td colspan="2">Driven or Estimated Length < 60 ft.
(0% capacity increase)</td><td colspan="2">Estimated Plan Pile Length > 60 ft.
(2% capacity increase)</td><td colspan="2">Driving Records Driven Length > 60 ft.
(4% capacity increase)</td></tr>
<tr><td>S_m</td><td>Borings Indicate Main Mode of Support</td><td>No Records Available
(0% cap. increase)</td><td>End Bearing in Soil or Shale
(0% cap. increase)</td><td>Friction in Granular Soils
(8% cap. increase)</td><td>Friction in Cohesive Soils
(16% cap. increase)</td><td>End Bearing in Sandstone
(16% cap. increase)</td><td>End Bearing in Limestone or Dolomite
(20% cap. increase)</td></tr>
</table>

Example: Existing plans pile data indicate timber piles, estimated to be 62 ft. long, with a design capacity of 24 tons. The pile driving records indicate that a MKT 11B3, a Closed and Air-Steam hammer, was used and on average the piles were driven 57 ft. with a final bearing of 30 tons.

The allowable resistance available $\mathbf{R_a}$, can be determined by the following formula: $\mathbf{R_a}$ = **Existing Capacity** x (1+$\mathbf{C_s}$+$\mathbf{C_b}$+$\mathbf{H_e}$+$\mathbf{P_e}$+$\mathbf{P_l}$+$\mathbf{S_m}$). The Exist Cap = 30 tons from driving records, $\mathbf{C_s}$ = 0.0 since we have driving records, $\mathbf{C_b}$ = 0.06 since the Exist Cap is below 40 tons, $\mathbf{H_e}$ = 0.08 due to the use of an Air-Steam Hammer, $\mathbf{P_e}$ = 0.0 because timber piles were used, $\mathbf{P_l}$ = 0.0 based on a driven length < 60 ft., and $\mathbf{S_m}$ = 0.0 since no borings are available. The factored resistance available $\mathbf{R_F}$ is determined by multiplying by the factor of safety which is assumed to be 3.0 and the resistance factor which is taken as 0.5.

$\mathbf{R_a}$ = 30 tons x (1+0+0.06+0.08+0+0+0) = 30 tons x 1.14 = 34.2 tons, 14% < 50% so OK.
$\mathbf{R_F}$ = R_a x (Safety Factor) x (Resistance Factor) = 34.2 x 3 x 0.5 x 2 kips/ton = 102.6 kips

The new factored strength group pile loading must not exceed the factored resistance available of 102.6 kips.

Spread Footing Foundations: Existing spread footings often have greater geotechnical capacity than indicated on the original plans when various factors are present. The table shown below and the example provide a method to calculate the potential increased capacity for existing structures. Settlement need not be checked when using this table.

Existing Spread Footing Capacity Determination Table:

R_a	No Borings Available (**2 ksf**)	Mixed soils with N >15 (**4 ksf**)	Clay soils with Q_u > 3.0 (**6 ksf)**	Very Dense Granular with N > 50 (**8 ksf**)	Hard Clay Till with Q_u > 4.5 (**10 ksf**)	Sandstone or Shale (**15 ksf**)	Limestone or Dolomite (**30 ksf**)

Example: Obtain the footing plan dimensions and base elevation from the existing plans. Calculate the existing and proposed footing loading to obtain the maximum applied service bearing pressure (**Q_{max}**) and resultant eccentricity. If the proposed Q_{max} is more than 50% above the existing loading, the footing cannot be reused. If founded on soil, calculate the proposed equivalent uniform bearing pressure (**Q_{EUBP}**). Using new or existing boring data, locate the footing base elevation and evaluate the soils/rock within a depth of 1.5 times the footing width to determine the allowable **service bearing capacity R_a** from the above table.

The proposed applied bearing pressure (Q_{max} for rock or Q_{EUBP} for soil) must be less than the allowable service bearing capacity R_a and the proposed resultant eccentricity must be within the middle third (for soil) or middle half (for rock) of the footing for the existing foundation to be considered adequate.

For both piles and spread footings, lateral loads to piles or sliding need not be checked unless the structure is in seismic categories C or D (AASHTO LFD) or seismic zones 3 or 4 (AASHTO LRFD). The allowable resistance available may be converted to factored resistance by multiplying by 1.5 (3.0 Factor of Safety times 0.5 resistance factor). The foundation element may be reused providing the following conditions exist:

(a) The Illinois Modified Group-1 load combination is below the actual calculated resistance available from the existing foundation as described above.
(b) The hydraulic analysis and soil conditions indicate no substantial scour.
(c) Deterioration has not compromised the structural integrity of the piles or footing.
(d) Inspections indicate no past foundation settlement.
(e) There is sufficient redundancy (more than 4 piles per foundation element).
(f) The increase in pile capacity or service bearing loading does not exceed 50%.