Appendix B: Stiffness Matrix of Building-Rocking Wall System

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% find the stiffness matrix of a building-rocking wall system
% get input
N = input('number stories: ');
L = input('total height (m): ');
h = L/N;
EI_wall = input('EI_wall (Nm^2): ');
bldg_storey_stiffness = input('bldg_storey_stiffness (N/m): ');
% wall stiffness matrix
F_wall_prime = zeros(N-1,N-1);
for i = 0:N-2;
        for j = 0:N-2;
                % find the rotation term
                moment_arm = (N-j)/N*L;
                single_storey_height = L/N;
                distance_to_point_measured_from_cantilever_root = (N-i)/N*L;
                rotation_at_lowest_storey = moment_arm*single_storey_height/(3*EI_wall);
                rotation_term =
                rotation_at_lowest_storey*distance_to_point_measured_from_cantilever_root;
                % find the cantilever term
                x = (N-i)/N*L; % the distance to the point measured from the cantilever root
                a = (N-j)/N*L; % the distance to the point of application of the load from the
                cantilever
                root
                if (j > i)
                        % must use the x > a cantilever formula
                        cantilever_term = a^2/(6*EI_wall)*(3*x - a);
                else
                        % must use the x <= a cantilever formula
                        cantilever_term = x^2/(6*EI_wall)*(-x + 3*a);
                end;
                F_wall_prime(i+1,j+1) = rotation_term + cantilever_term;
        end;
end;
K_wall_prime = inv(F_wall_prime);
K_wall = zeros(N,N); % works
for i = 1:N-1;
        for j = 1:N-1;
                K_wall(i,j) = K_wall_prime(i,j);
        end;
end;
% building stiffness matrix
Sum_bldg_stiffness = bldg_storey_stiffness;
K_bldg = zeros(N,N);
for j = 1:N-1;
        % diagonals
        K_bldg(j,j) =K_bldg(j,j) + Sum_bldg_stiffness;
        K_bldg(j+1,j+1)=K_bldg(j+1,j+1)+ Sum_bldg_stiffness;
        % off diagonals
        K_bldg(j,j+1)= -Sum_bldg_stiffness;
        K_bldg(j+1,j)= -Sum_bldg_stiffness;
end;
% now increase the bottom-right element by JUST Sum_bldg_stiffness to finish the matrix
K_bldg(N,N)=K_bldg(N,N) + Sum_bldg_stiffness;
% I_prime
I_prime = zeros(N,N);
for j = 1:N-1;
        % diagonals
        I_prime(j,j) = 1;
end;
% L_N = "linear-N"
L_N = zeros(N,N);
for j = 1:N;
        % end of each row
        L_N(j,N) = N-j+1;
end;
% moments matrix
M = zeros(N,N);
for j = 1:N-1;
        % diagonals
        M(N,j) = -(N-j+1);
end;
% total stiffness matrix
K_total = K_bldg + (M + eye(N))*K_wall*(eye(N) - L_N);
```