Time Histories

At this point we covered:

1) Ground Motion Parameters
2) Attenuation Relationships
3) Seismic Hazard Analysis (DSHA & PSHA)
4) Response Spectra

Now let's talk a little bit about how to use these things to develop time histories that can be used for design of tailing dams

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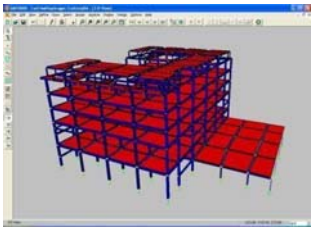
Time History Analysis

Time history analysis is the use of an earthquake time history to evaluate the response of your system. Can be performed for both structures and soil.



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Time History Analysis

Ideally, we want to use time histories that are reasonably close to our design response spectrum

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Time History Analysis

There are two main methods we use to get our time histories to match the design spectrum:

1. Time History Scaling

2. Spectral Matching

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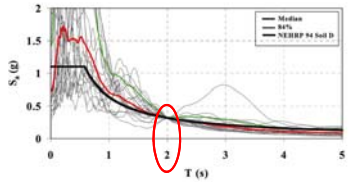
Time History Scaling

Time history scaling involves modifying a time history's **Scale** and/or **Time Step** in order to try to closely match the design response spectrum.



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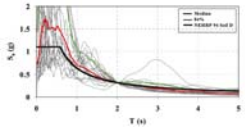
Time History Scaling

In addition, we try to make the smoothed average spectrum fall within a specified tolerance of the target spectrum.



Because it's impossible to get this tolerance over the entire spectrum, we typically focus on the period range of interest: **Often $0.2T_N$ to $1.5T_N$**

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Time History Scaling

Advantages:	Disadvantages:
1) Uses "Real" EQ Time histories	1) Usually requires LOTS of time histories
2) Retains natural variances in the EQ time histories	2) Greater variance in your computed response
3) Allows you to focus response on the period(s) of interest	3) Can take a lot of time to do.
4) Relatively easy to do with proper tools	

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Spectral Matching

Spectral matching involves a time domain modification of an acceleration time history to make it compatible with a user-specified target spectrum. Based on the original method proposed by Lilhanand and Tseng (1987, 1988).

Abrahamson (1993) wrote the first widely-used computer code for spectral matching called RSPMatch. It has been subsequently updated.

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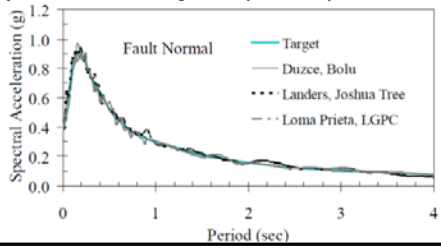
Spectral Matching

Spectral matching has the advantage of significantly reducing variability in the computed response because the time histories are often very close to the target response spectrum



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Spectral Matching

Advantages:

1) Less variability

2) Usually requires fewer ground motions

3) Sometimes easier to spot design flaws from the system response

Disadvantages:

1) Can result in unrealistic EQ ground motions

2) Certain valuable aspects of EQ time history can be lost

3) Can take a lot of time to do correctly

4) Easy to screw up if you don't know what you're doing

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Selecting Time Histories

Part of the challenge of developing time histories is selecting appropriate time histories to use.

What kinds of factors should we consider when selecting time histories?

-Magnitude (within ± 1 Mag)

-Distance (within ±10 km if possible)

-Faulting mechanism (more important for reverse/thrust faults, subduction zones)

-Arias Intensity

-Spectral Acceleration (within 20-30% at the natural period(s) of interest, if possible)

-Soil/Rock Type (same site class)

-Directivity effects (if applicable)

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Selecting Time Histories

I prefer to use the time histories from the PEER NGA database because they have undergone significant reviews, and the search functions are extremely handy.

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Evaluating Your Results

How can you tell if your spectrally-matched time history is good? Norm Abrahamson (the developer of RSPMatch) was asked in 2008 how many time histories he throws out when he performs spectral matching. His response:

"I throw out about *80%* of my spectrally-matched time histories."

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Evaluating Your Results

Here are some things to look for:

1) Plot the acceleration, velocity, and displacement plots for both the pre- and post-matched time histories. Make sure that significant peaks in the governing motion aren't altered too much.
2) Make sure that the desired aspects of the ground motion (e.g. directivity) are still there after the spectral matching.
3) Compare the pre- and post-matching Arias Intensity plots. Make sure that the energy run-up hasn't been significantly altered.

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Spectral Matching Tips

Here are some tips to help improve your spectral matching:

1) Don't specify too high of a tolerance. If you are developing 7 sets of time histories, a tolerance of 20-30% should be fine. If you are only developing 3 sets or less, then you should try to get a tighter tolerance (10-15%).
2) Performing 2 passes will make your matching look better. Perform the first pass matching periods between 0.01-1.0 second. On the second pass, increase the period range to 0.01-10 seconds. You may need to adjust the default settings to allow you to specify these periods.

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Final Spectral Matching Advice

Be careful! Software such as *SeismoMatch* has simplified spectral matching to the point that nearly anybody can do it. But spectral matching is like using a gun….. It may seem easy to do, but you can really hurt yourself if you don't know what you're doing.

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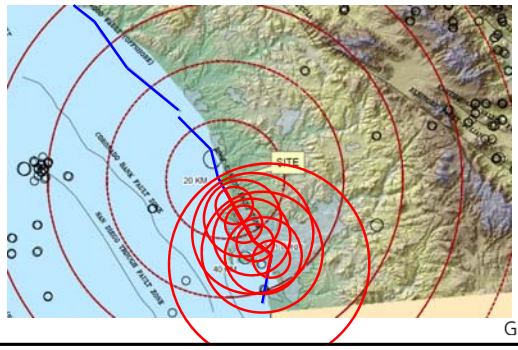
Directivity Effects on Ground Motions



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Selection and modification of time histories

Time history selection from PEER/NGA database considering consistency with the following seismic parameters:
- Near-source forward directivity
- Faulting mechanism: strike-slip
- Magnitude ~ 7.0
- Closest distance ~ 3 km
- PGA ~ 0.6 g
- Site soil condition: Soil profile Type D

↓

Vector rotation of selected time histories to fault normal (FN) and fault parallel (FP) components

↓

Vector rotation from fault normal (FN) and fault parallel (FP) relative to Rose Canyon fault to transverse and longitudinal components relative to bridge axis

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Baseline correction

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Spectral Matching

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Second baseline correction

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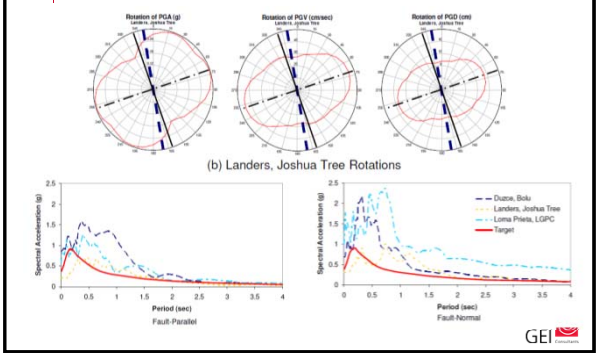
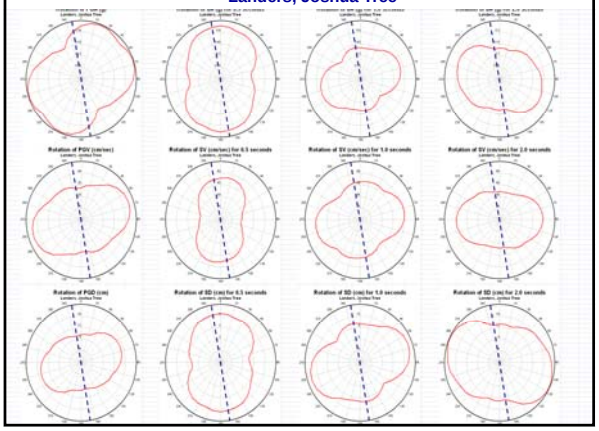
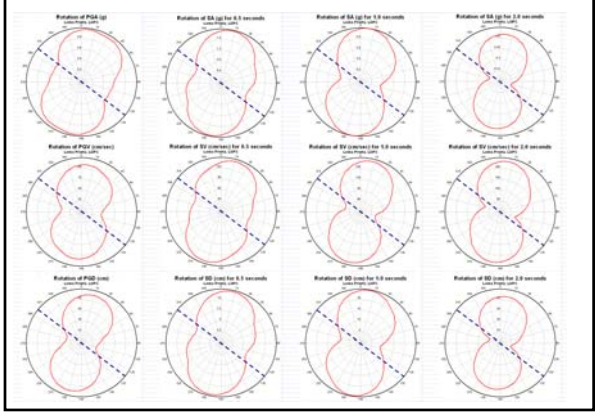
Directivity of Seed Time Histories



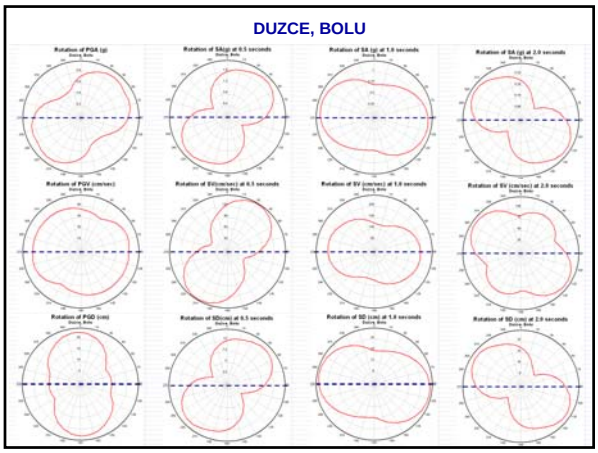
Landers, Joshua Tree

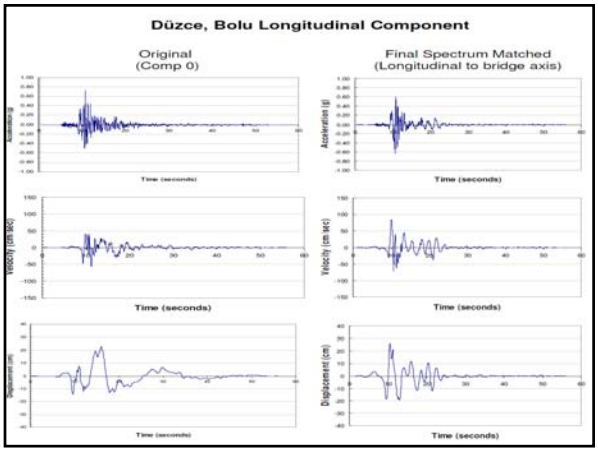


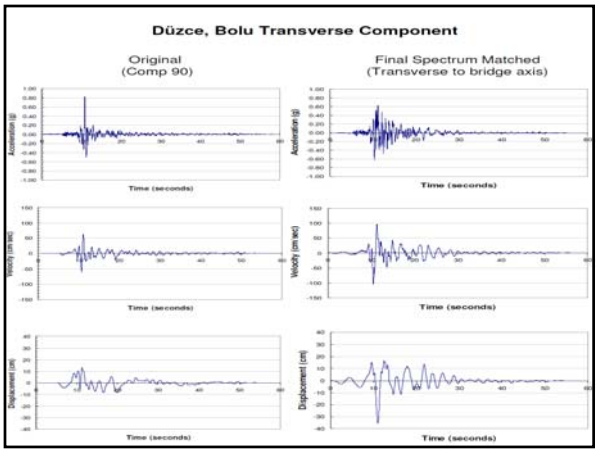
Loma Prieta, LGPC

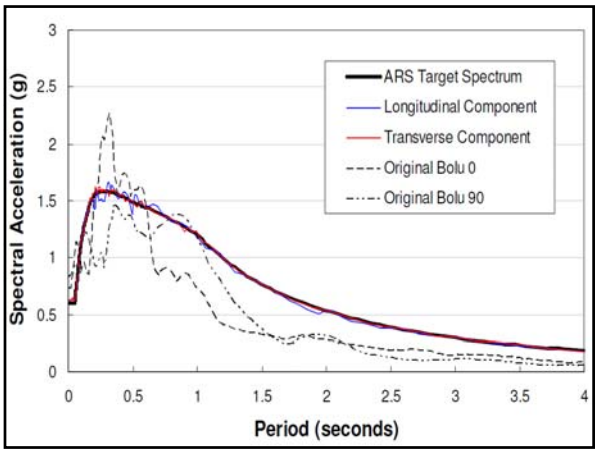


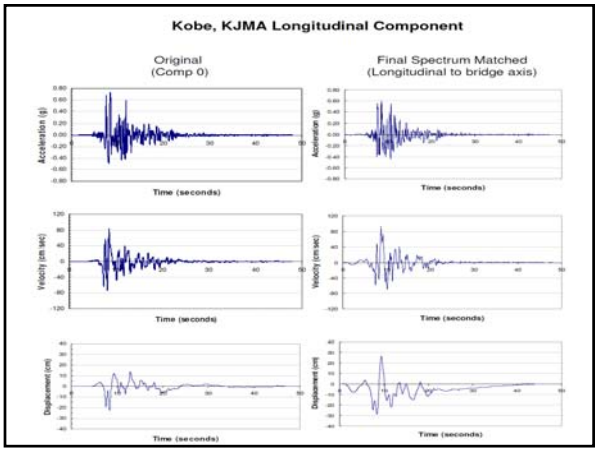
DUZCE, BOLU

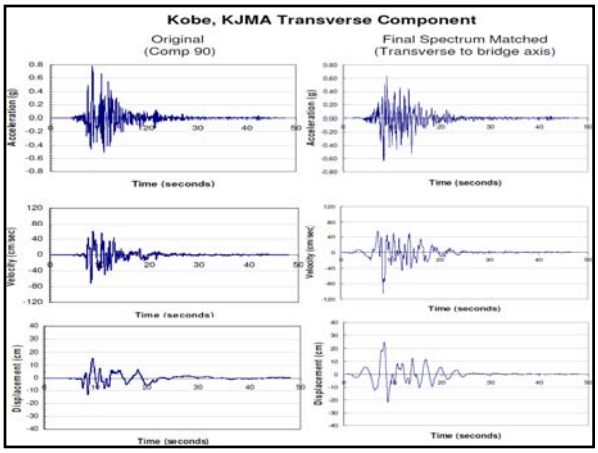


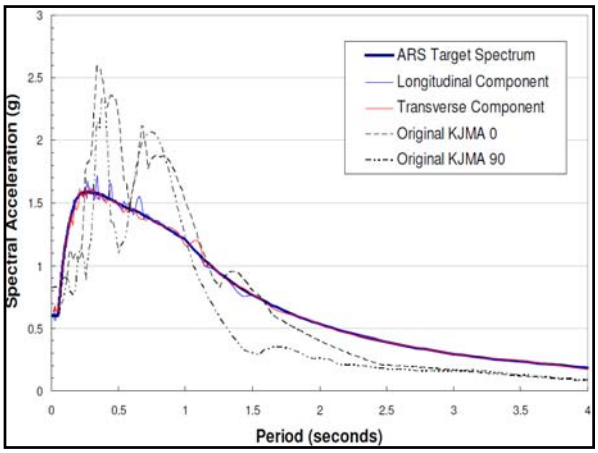

Düzce, Bolu Longitudinal Component
Original
(Comp 0)
Final Spectrum Matched
(Longitudinal to bridge axis)
Time (seconds)

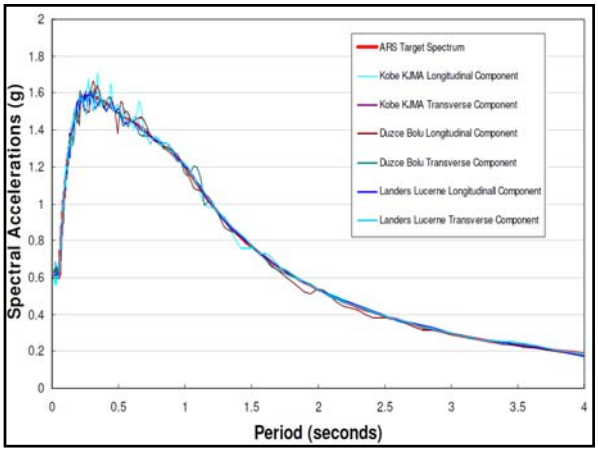

Düzce, Bolu Transverse Component
Original
(Comp 90)
Final Spectrum Matched
(Transverse to bridge axis)
Time (seconds)

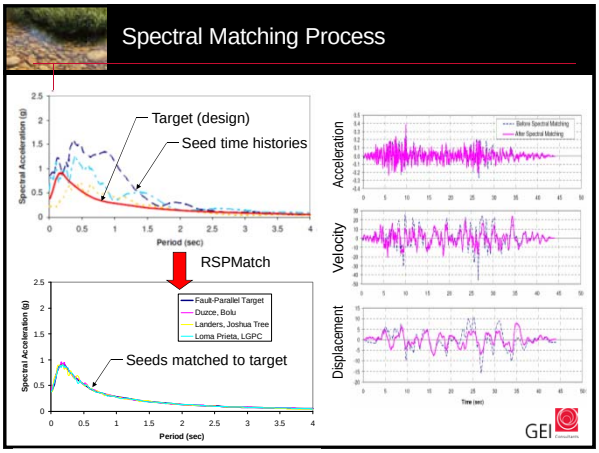

Spectral Acceleration (g)
Period (seconds)
ARS Target Spectrum
Longitudinal Component
Transverse Component
Original Bolu 0
Original Bolu 90


Kobe, KJMA Longitudinal Component
Original
(Comp 0)
Final Spectrum Matched
(Longitudinal to bridge axis)
Time (seconds)


Kobe, KJMA Transverse Component
Original
(Comp 90)
Final Spectrum Matched
(Transverse to bridge axis)
Time (seconds)


ARS Target Spectrum
Longitudinal Component
Transverse Component
Original KJMA 0
Original KJMA 90
Spectral Acceleration (g)
Period (seconds)


ARS Target Spectrum
Kobe KJMA Longitudinal Component
Kobe KJMA Transverse Component
Duzce Bolu Longitudinal Component
Duzce Bolu Transverse Component
Landers Lucerne Longitudinall Component
Landers Lucerne Transverse Component
Spectral Accelerations (g)
Period (seconds)


Spectral Matching Process
Target (design)
Seed time histories
RSPMatch
Seeds matched to target
Fault-Parallel Target
Duzce, Bolu
Landers, Joshua Tree
Loma Prieta, LGPC
Period (sec)
Acceleration
Velocity
Displacement
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Gracias por su atencion!

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