

# APPENDIX E

## Clustering Analysis Test Results

### Clustering Raw Data

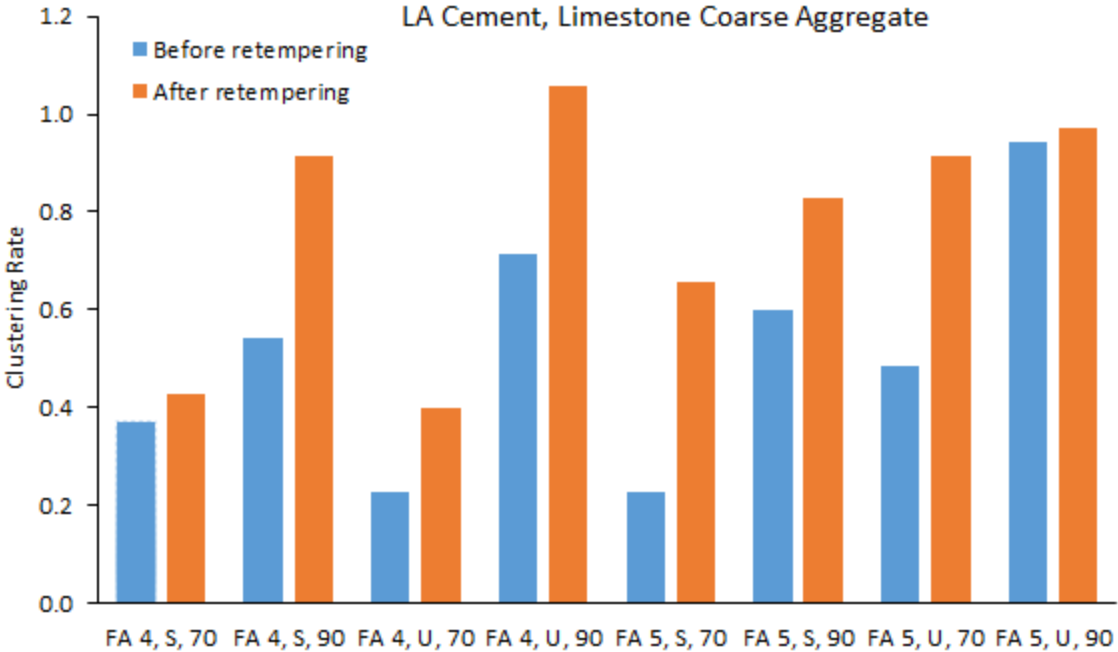
**Table E-1. Summary of clustering analysis data.**

| Mix# | Clustering Rate |       | Fresh Air (%) |       | 7-day Comp. Strength (psi) |       | 28-day Comp. Strength (psi) |       | 7-day Splitting Tensile Strength (psi) |       |
|------|-----------------|-------|---------------|-------|----------------------------|-------|-----------------------------|-------|--|-------|
|      | Before          | After | Before        | After | Before                     | After | Before                      | After | Before                                 | After |
| 1    | 0.57            | 0.66  | 6.2           | 4.3   | 5,320                      | 4,900 | 6,840                       | 6,240 | NA                                     | NA    |
| 2    | 0.66            | 0.60  | 6.3           | 5.0   | 5,445                      | 5,525 | 6,355                       | 6,600 | NA                                     | NA    |
| 3    | 0.69            | 0.74  | 5.0           | 3.9   | 4,370                      | 4,645 | 5,590                       | 5,305 | NA                                     | NA    |
| 4    | 0.40            | 0.54  | 6.0           | 3.8   | 3,945                      | 4,180 | 5,735                       | 5,880 | NA                                     | NA    |
| 5    | 0.69            | 0.69  | 6.7           | 7.2   | 4,845                      | 4,445 | 5,865                       | 5,770 | NA                                     | NA    |
| 6    | 0.69            | 0.71  | 6.0           | 6.1   | 4,665                      | 4,470 | 6,025                       | 5,070 | NA                                     | NA    |
| 7    | 0.69            | 0.77  | 5.7           | 5.6   | 4,080                      | 3,035 | 5,305                       | 4,560 | NA                                     | NA    |
| 8    | 0.71            | 0.94  | 5.8           | 6.3   | 4,030                      | 3,665 | 4,595                       | 4,235 | NA                                     | NA    |
| 9    | 0.71            | 0.86  | 6.3           | 8.0   | 5,460                      | 3,970 | 6,635                       | 4,915 | NA                                     | NA    |
| 10   | 0.69            | 0.89  | 6.1           | 7.9   | 4,885                      | 4,130 | 5,595                       | 5,105 | NA                                     | NA    |
| 11   | 0.69            | 0.77  | 6.9           | 7.2   | 4,050                      | 3,635 | 4,775                       | 3,890 | NA                                     | NA    |
| 12   | 0.57            | 0.63  | 5.6           | 5.6   | 4,690                      | 3,985 | 5,910                       | 4,980 | NA                                     | NA    |
| 13   | 0.60            | 0.66  | 5.2           | 5.3   | 5,500                      | 4,710 | 6,420                       | 5,925 | NA                                     | NA    |
| 14   | 0.34            | 0.57  | 5.5           | 6.0   | 5,235                      | 4,525 | 5,910                       | 4,980 | NA                                     | NA    |
| 15   | 0.63            | 0.74  | 5.0           | 4.9   | 4,410                      | 3,940 | 5,660                       | 5,500 | NA                                     | NA    |
| 16   | 0.80            | 0.86  | 7.0           | 7.3   | 3,830                      | 3,440 | 4,455                       | 4,210 | NA                                     | NA    |
| 17   | 0.37            | 0.43  | 5.6           | 2.9   | 5,170                      | 4,910 | 6,905                       | 6,550 | NA                                     | NA    |
| 18   | 0.54            | 0.91  | 6.6           | 6.6   | 4,165                      | 3,780 | 5,185                       | 5,340 | NA                                     | NA    |
| 19   | 0.20            | 0.29  | 5.5           | 6.0   | 4,525                      | 3,955 | 6,015                       | 5,530 | NA                                     | NA    |
| 20   | 0.23            | 0.54  | 5.4           | 6.6   | 4,865                      | 4,340 | 6,095                       | 5,815 | NA                                     | NA    |
| 21   | 0.23            | 0.40  | 5.0           | 4.5   | 4,960                      | 4,845 | 6,690                       | 6,595 | NA                                     | NA    |
| 22   | 0.71            | 1.06  | 6.3           | 6.9   | 3,705                      | 3,595 | 4,995                       | 4,915 | NA                                     | NA    |
| 23   | 0.40            | 0.51  | 5.1           | 5.0   | 4,445                      | 4,000 | 5,745                       | 5,545 | NA                                     | NA    |
| 24   | 0.29            | 0.63  | 5.0           | 5.3   | 4,620                      | 4,095 | 6,150                       | 5,605 | NA                                     | NA    |
| 25   | 0.23            | 0.66  | 5.2           | 6.5   | 4,980                      | 4,300 | 6,550                       | 5,865 | NA                                     | NA    |
| 26   | 0.60            | 0.83  | 6.7           | 7.4   | 4,255                      | 4,040 | 5,760                       | 5,435 | NA                                     | NA    |
| 27   | 0.17            | 0.57  | 5.0           | 6.4   | 4,895                      | 4,315 | 6,200                       | 5,675 | NA                                     | NA    |
| 28   | 0.43            | 0.57  | 5.1           | 5.3   | 4,845                      | 4,360 | 6,290                       | 5,595 | NA                                     | NA    |

| Mix# | Clustering Rate |       | Fresh Air (%) |       | 7-day Comp. Strength (psi) |       | 28-day Comp. Strength (psi) |       | 7-day Splitting Tensile Strength (psi) |       |
|------|-----------------|-------|---------------|-------|----------------------------|-------|-----------------------------|-------|--|-------|
|      | Before          | After | Before        | After | Before                     | After | Before                      | After | Before                                 | After |
| 29   | 0.49            | 0.91  | 5.4           | 7.9   | 4,960                      | 3,700 | 6,390                       | 4,985 | NA                                     | NA    |
| 30   | 0.94            | 0.97  | 5.6           | 6.5   | 3,805                      | 3,355 | 4,890                       | 4,440 | NA                                     | NA    |
| 31   | 0.14            | 0.34  | 5.5           | 6.0   | 4,785                      | 4,140 | 5,795                       | 5,530 | NA                                     | NA    |
| 32   | 0.66            | 0.89  | 6.7           | 7.6   | 3,635                      | 3,420 | 4,865                       | 4,620 | NA                                     | NA    |
| 33   | 0.49            | 0.74  | 6.1           | 5.9   | 5,040                      | 4,395 | 5,405                       | 4,860 | NA                                     | NA    |
| 34   | 0.34            | 0.63  | 5.2           | 4.6   | 5,165                      | 4,575 | 5,860                       | 5,695 | NA                                     | NA    |
| 35   | 0.51            | 0.54  | 5.0           | 4.2   | 4,275                      | 4,255 | 5,595                       | 5,595 | NA                                     | NA    |
| 36   | 0.46            | 0.57  | 6.4           | 5.9   | 4,130                      | 4,040 | 5,640                       | 4,785 | NA                                     | NA    |
| 37   | 0.49            | 0.69  | 5.4           | 6.1   | 4,630                      | 4,145 | 5,795                       | 4,950 | NA                                     | NA    |
| 38   | 0.51            | 0.60  | 5.1           | 6.4   | 4,920                      | 4,320 | 5,670                       | 4,985 | NA                                     | NA    |
| 39   | 0.66            | 0.86  | 5.3           | 6.0   | 4,625                      | 4,360 | 5,355                       | 4,995 | NA                                     | NA    |
| 40   | 0.66            | 0.66  | 5.4           | 5.5   | 4,655                      | 4,315 | 5,780                       | 5,730 | NA                                     | NA    |
| 41   | 0.49            | 0.77  | 6.7           | 7.7   | 4,790                      | 4,165 | 5,365                       | 5,270 | NA                                     | NA    |
| 42   | 0.40            | 0.71  | 6.8           | 7.7   | 4,860                      | 4,000 | 6,070                       | 5,095 | NA                                     | NA    |
| 43   | 0.29            | 0.63  | 6.3           | 6.1   | 4,695                      | 4,035 | 5,700                       | 5,470 | NA                                     | NA    |
| 44   | 0.43            | 0.46  | 5.8           | 6.8   | 5,065                      | 4,540 | 6,260                       | 5,705 | NA                                     | NA    |
| 45   | 0.43            | 0.60  | 5.0           | 6.3   | 5,555                      | 4,205 | 5,950                       | 5,155 | NA                                     | NA    |
| 46   | 0.63            | 0.77  | 6.4           | 7.8   | 5,215                      | 4,075 | 6,370                       | 5,055 | NA                                     | NA    |
| 47   | 0.43            | 0.77  | 5.8           | 7.8   | 4,680                      | 3,885 | 5,805                       | 4,905 | NA                                     | NA    |
| 48   | 0.49            | 0.83  | 6.6           | 10.0  | 4,090                      | 3,190 | 5,030                       | 4,265 | NA                                     | NA    |
| 49   | 0.43            | NA    | 5.5           | NA    | 3,465                      | NA    | 4,521                       | NA    | NA                                     | NA    |
| 50   | 0.63            | NA    | 5.6           | NA    | 3,379                      | NA    | 4,097                       | NA    | NA                                     | NA    |
| 51   | 0.74            | NA    | 5.4           | NA    | 3,937                      | NA    | 5,011                       | NA    | NA                                     | NA    |
| 52   | 0.40            | NA    | 6.5           | NA    | 3,168                      | NA    | 4,124                       | NA    | NA                                     | NA    |
| 53   | 0.30            | NA    | 6.5           | NA    | 3,915                      | NA    | 5,115                       | NA    | NA                                     | NA    |
| 54   | 0.60            | NA    | 6.5           | NA    | 4,185                      | NA    | 5,461                       | NA    | NA                                     | NA    |
| 55   | 0.74            | 0.8   | 5.3           | 7.3   | 3,465                      | 3,040 | NA                          | NA    | 320                                    | 310   |
| 56   | 0.31            | 0.57  | 4.2           | 5.2   | 4,615                      | 4,077 | NA                          | NA    | 330                                    | 280   |
| 57   | 0.74            | 0.97  | 5.9           | 7.0   | 3,892                      | 3,131 | NA                          | NA    | 350                                    | 330   |
| 58   | 0.29            | 0.29  | 6.2           | 5.1   | 3,533                      | 3,647 | NA                          | NA    | 360                                    | 420   |
| 59   | 0.74            | 0.86  | 6.9           | 9.7   | 3,431                      | 2,781 | NA                          | NA    | 320                                    | 260   |
| 60   | 0.14            | NA    | 5.6           | NA    | 4,019                      | NA    | NA                          | NA    | 335                                    | NA    |
| 61   | 0.20            | NA    | 5.4           | NA    | 4,015                      | NA    | NA                          | NA    | 400                                    | NA    |

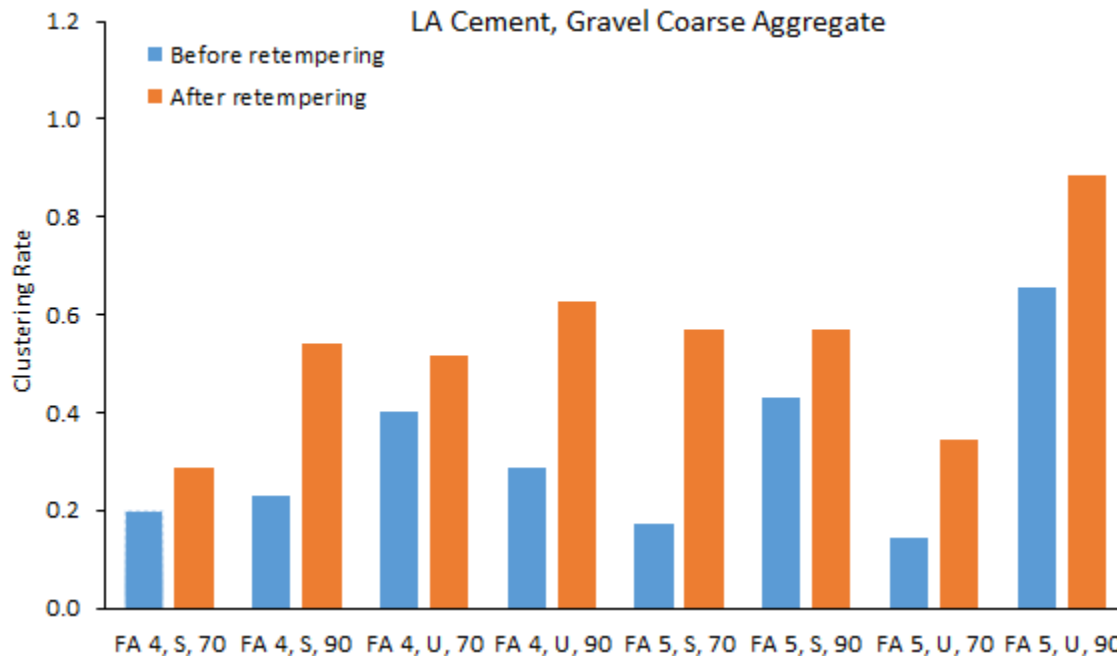
Note: Comp. = compressive, NA = not available.

*Effect of Mixture Proportions on Clustering*



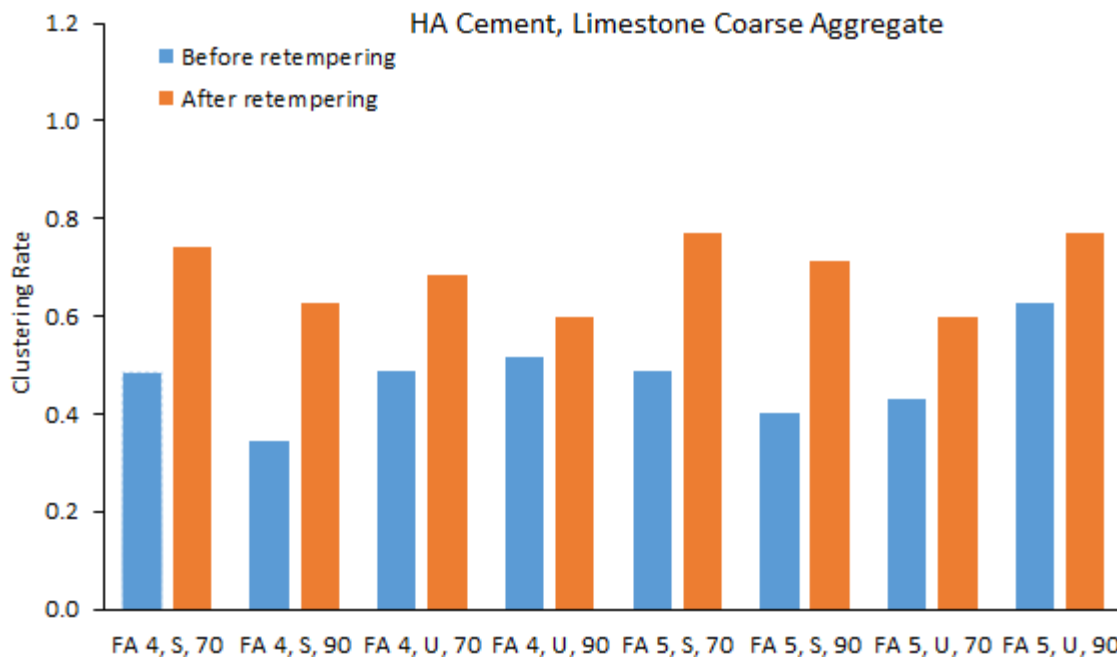
Note: FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-1. Clustering rates for mixtures prepared with LA cement and coarse limestone aggregate.**



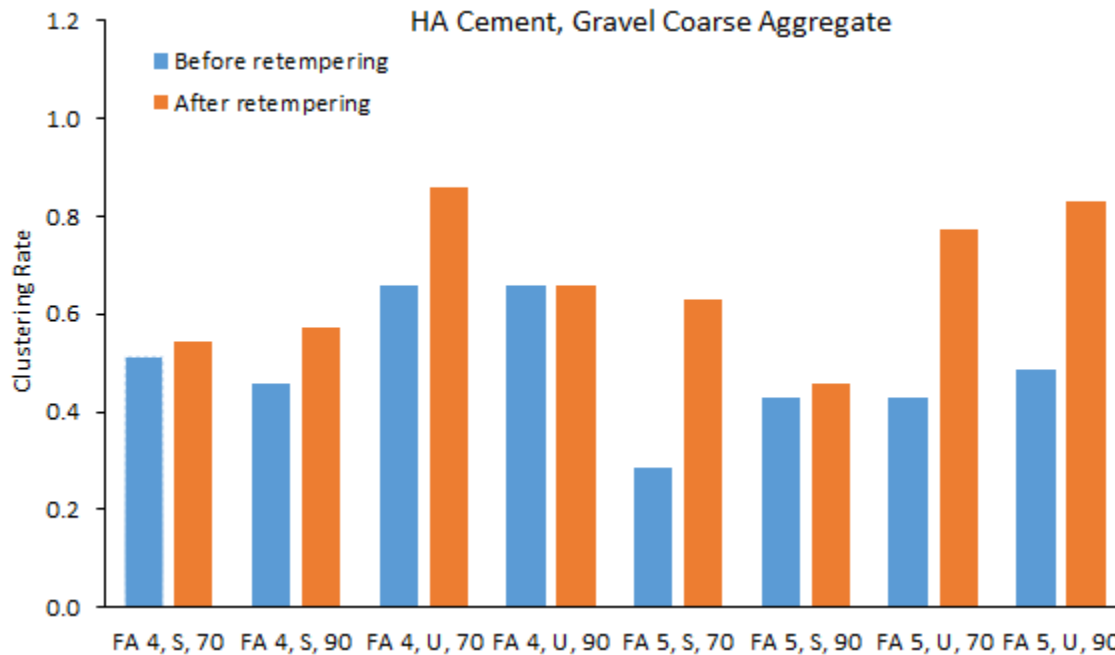
Note: LA = low-alkali, FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-2. Clustering rates for mixtures prepared with LA cement and coarse gravel aggregate.**



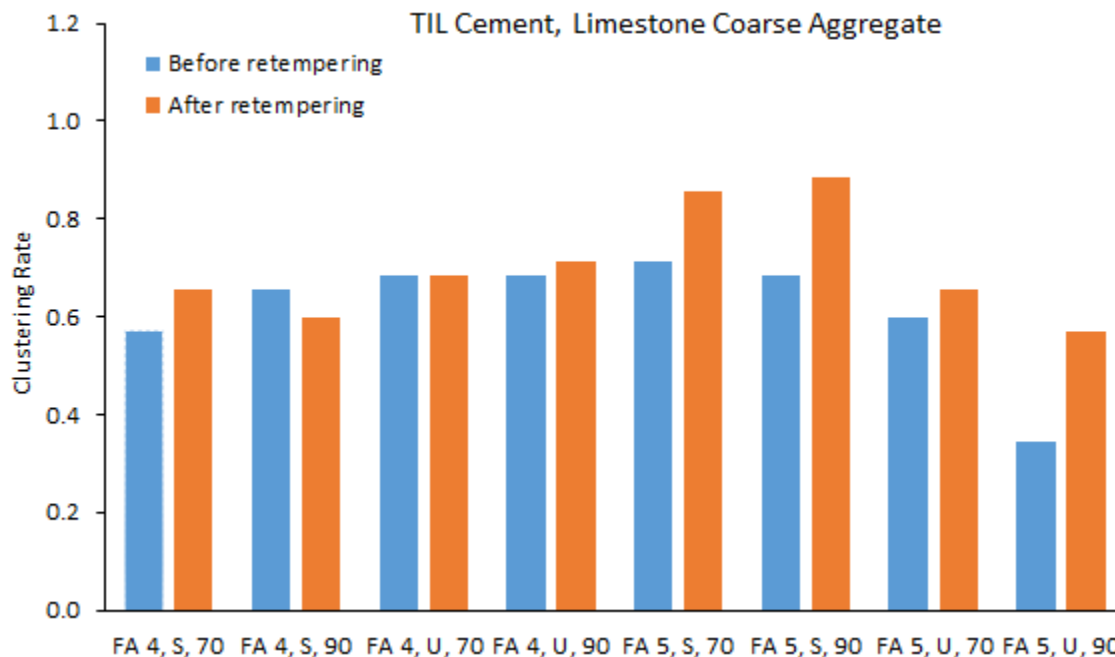
Note: HA = high-alkali, FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-3. Clustering rates for mixtures prepared with HA cement and coarse limestone aggregate.**



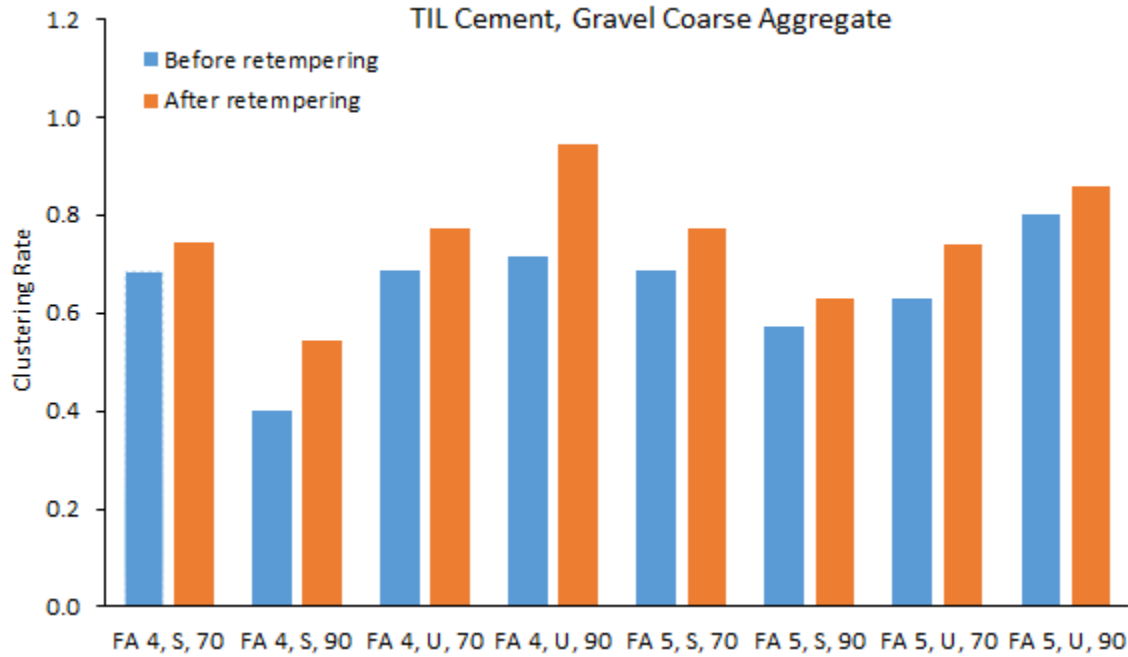
Note: HA = high-alkali, FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-4. Clustering rates for mixtures prepared with HA cement and coarse gravel aggregate.**



Note: FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-5. Clustering rates for mixtures prepared with TIL cement and coarse limestone aggregate.**



Note: FA 4 = low-quality fly ash, FA 5 = high-quality fly ash, S = stable AEA, U = unstable AEA, 70 and 90 = temperature of mixing water in °F.

**Figure E-6. Clustering rates for mixtures prepared with TIL cement and coarse gravel aggregate.**

Effects of Clustering on Compressive Strength

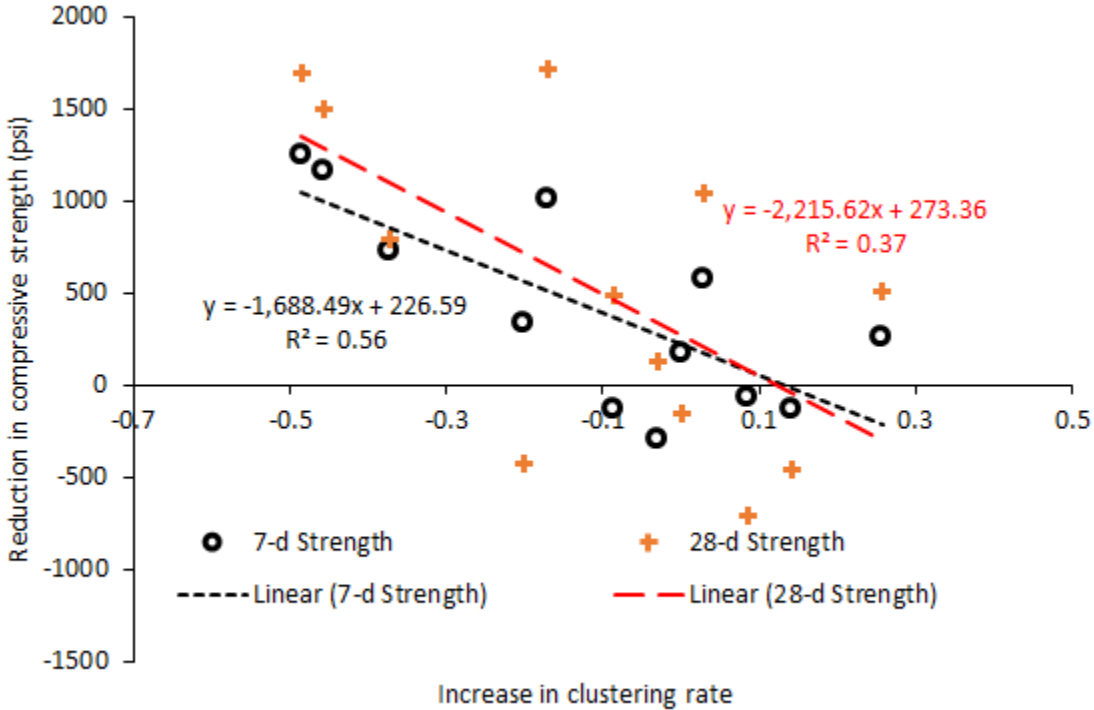
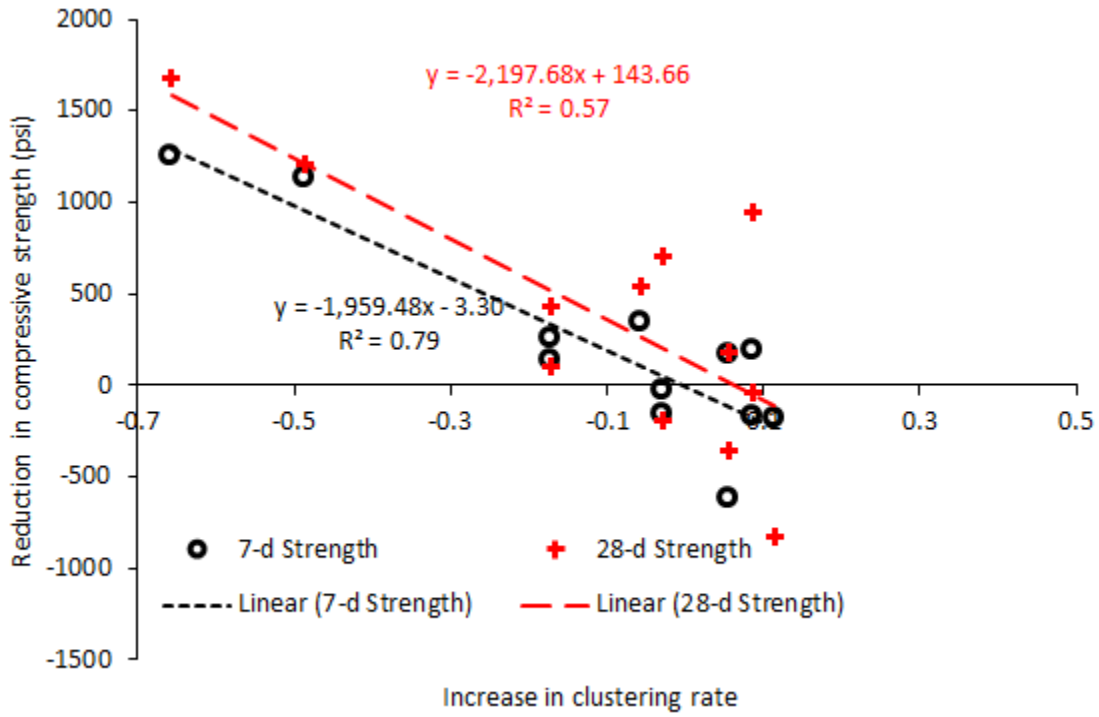
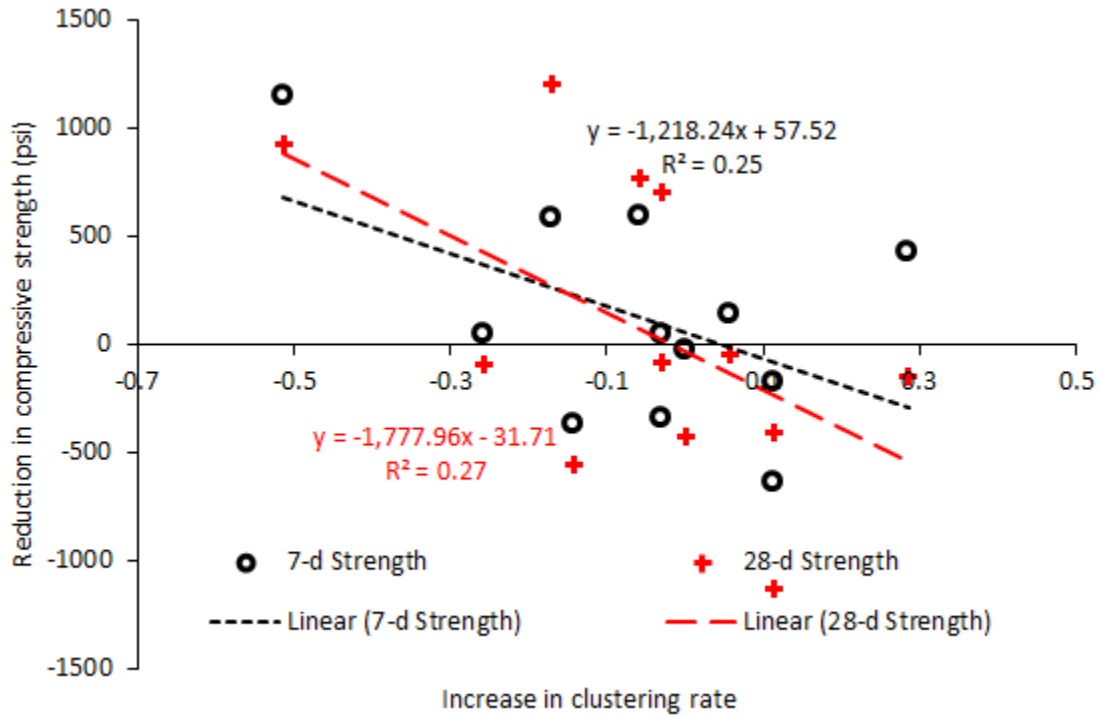


Figure E-7. Variation in compressive strength as a function of variations in clustering rate, before retempering, for concrete made with coarse limestone aggregate.

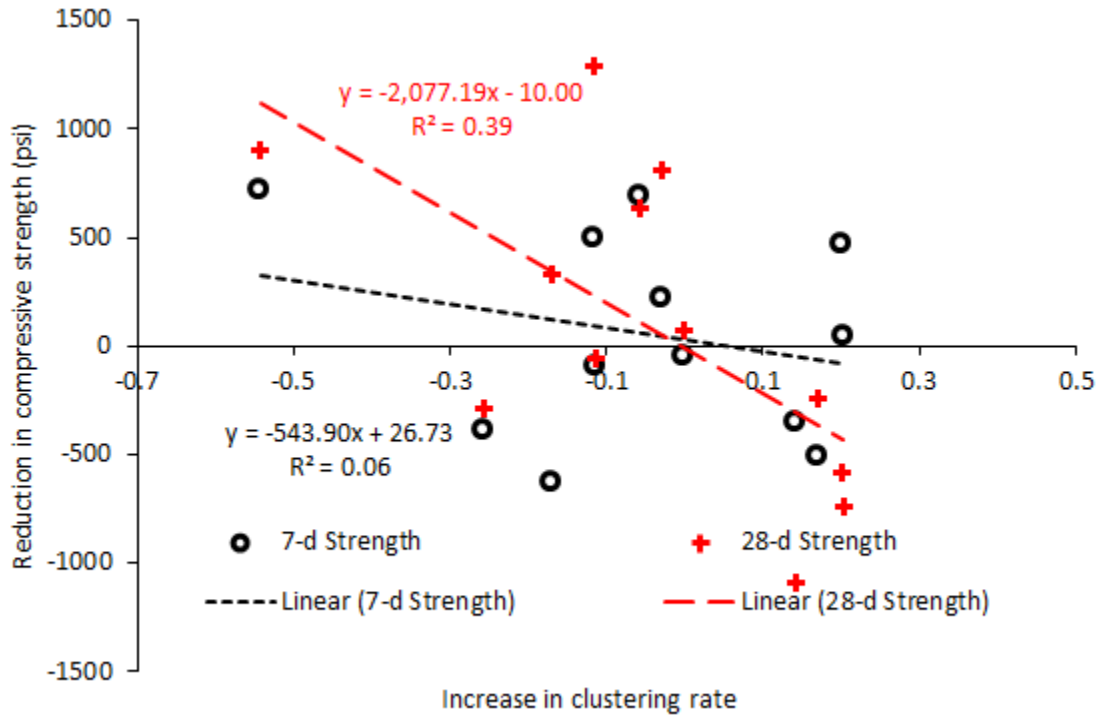


**Figure E-8. Variation in compressive strength as a function of variations in clustering rate, after retempering, for concrete made with coarse limestone aggregate.**





**Figure E-9. Variation in compressive strength as a function of variations in clustering rate, before retempering, for concrete made with coarse gravel aggregate.**



**Figure E-10. Variation in compressive strength as a function of variations in clustering rate, after retempering, for concrete made with coarse gravel aggregate.**