Accelerated bridge construction (ABC) is being increasingly used in new bridge construction and repair. ABC typically requires prefabricated elements joined with mechanical couplers. Grouted sleeves (GSs) offer good construction tolerances and load transfer between precast elements. However, previous research identified some performance issues with precast columns employing GS connections for seismic regions. Therefore, there is a need to develop improved connection details. This research consists of three components; testing of six large-scale precast reinforced concrete column models, a series of individual component tests on GS bar splices, and analytical studies. Large-scale, precast column models were designed and experimentally tested using a shifted plastic hinge (SPH) concept to minimize the damage in the capacity-protected elements and retain the column ductility. The column testing matrix considered aspect ratio, moment gradient, and splicing details. Column models were tested in an upright cantilever configuration under quasi-static cyclic load. Results showed that SPH can be used for both flexural and flexural-shear columns. Two types of component tests were performed: tensile tests to quantify the tensile behavior of the splices, and strain penetration tests to quantify the slip at the sleeve ends. The tests were used to obtain constitutive models for the bond-slip behavior of the GS splices. Results showed that GS splices developed the full ultimate stress of the spliced bars and that the slip at sleeve ends can considerably influence the global behavior of the precast columns. The analytical models were developed in OpenSeeS using fiber-based beams models and they incorporated the calibrated bond-slip models of GS splices. The large-scale column tests were simulated and compared with respective experimental results. Analytical results showed that the developed models were able to mimic the column behavior and can be used for analysis of GS precast columns.