6-04.1 SHOULDER TYPES. Shoulders adjacent to either rigid or flexible pavements are constructed from several distinct materials depending on the traffic and expected use of the shoulder. Earth shoulders are provided in areas where minimal use of the shoulder is expected. Aggregate stabilized shoulders and paved shoulders consisting of either asphalt or concrete are normally used in all other areas.

6-04.1 (1) EARTH SHOULDERS. When earth shoulders are recommended, consideration is given to careful selection of soils which have low shrink and swell characteristics and which are relatively permeable. Heavy, plastic, and high volume change soils are avoided if possible since they lead to wide shrinkage cracks along the traveled way edges. In general, soils with plasticity indexes less than 25, and volume change characteristics less than 45 percent will give satisfactory results. District soils and geology technologists are available to help locate suitable materials for shoulder construction. At some locations soil properties may be unsuitable for use as earth shoulders and if recommended by the district operations engineer aggregate stabilization may be considered.

6-04.1 (2) STABILIZED SHOULDERS. Aggregate stabilized shoulders and paved shoulders provide a more secure surface to accommodate vehicles for emergencies and other uses. Paved shoulders are an integral part of the pavement structure and are considered as part of the pavement design configuration.

6-04.2 SHOULDER TYPE SELECTION. Shoulder types are selected based on pavement classification and design year average daily traffic. Shoulders are further classified by type for the various categories.

6-04.2 (1) LIGHT DUTY PAVEMENT

6-04.2 (1) (a) RIGID & FLEXIBLE - WITH LESS THAN 400 ADT. Earth shoulders, Type E, are provided. Aggregate stabilized shoulders, Type D, consisting of a 3 in. [75 mm] thickness of Type 1 Aggregate may be recommended by the district operations engineer and justified based on soil properties. See Figure 6-03.1.

6-04.2 (1) (b) RIGID & FLEXIBLE - WITH 400 TO 750 ADT. Aggregate stabilized shoulders, Type D, are provided. They consist of a 3 in. [75 mm] thickness of Type 1 aggregate. Type C aggregate stabilized shoulders may be provided if recommended by the district operations engineer and justified based on soil properties. See Figure 6-03.1.

6-04.2 (1) (c) RIGID & FLEXIBLE - WITH 750 TO 1700 ADT. Aggregate stabilized shoulders, Type C, are provided. The stabilized shoulder material consists of 6 in. [150 mm] Type 1 aggregate and is placed directly on the compacted subgrade. See Figure 6-03.1.

6-04.2 (1) (d) RIGID & FLEXIBLE - WITH 1700 to 3500 ADT. Aggregate stabilized shoulders, Type B, are provided. They consist of 8 in. [200 mm] Type 1 aggregate and is placed directly on the compacted subgrade. Pavement widths for roadways with 1700 to 3500 ADT are widened by 2 ft. [0.6 m] and delineated at the edge of the travel lane by appropriate lane marking. See Figure 6-03.2.

6-04.2 (1) (e) RIGID & FLEXIBLE - WITH OVER 3500 ADT. Paved shoulders, Type A1 or A2, are provided. Type A1 shoulders are provided on the median side of dual lane facilities. They consist of the same material and thickness as the roadway pavement and are an integral part of the pavement structure. The pavement width is widened 4 ft. [1.2 m] and there is no longitudinal joint between the Type A1 paved shoulder and mainline pavement. Type A2 shoulders for flexible pavement consist of 5-$^{3}/_{4}$ in. [145 mm] of asphaltic concrete and the pavement width is widened by 2 ft. [0.6 m]. Quantities for base for Type A2 shoulders should be estimated for mainline base, as shown on the special sheet entitled "Type A2 Shoulders for Light Duty Pavements." For rigid pavement, options should be provided. These options include 6" tied concrete shoulders, tied concrete shoulders that are 6" minimum on the outside edge, or asphalt shoulders. For those

projects that are alternate pavement projects with optional shoulder types the Life Cycle Cost Adjustment Factor shall be calculated for mainline pavement only. Superpave mixtures may be substituted for Type A2 shoulders if Superpave mixtures are used elsewhere on the project. For flexible pavement, the Type A2 shoulder should be of the same material as the traveled way. For Type A1 and A2 shoulders, the edge of the travel lane is delineated by appropriate lane marking. See Figures 6-03.3, 6-03.4 and 6-03.5.

6-04.2 (2) MEDIUM DUTY PAVEMENT RIGID & FLEXIBLE - ALL ADT's. Paved shoulders, Type A or A1, are provided. Type A and A1 shoulders consist of the same material and thickness as the roadway pavement and are an integral part of the pavement structure. Type A shoulders are provided next to the outside traveled way, the pavement width is widened by 2 ft. [0.6 m] and the rigid shoulder is tied to the pavement structure with tie bars. Type A1 shoulders are provided on the median side of dual lane facilities, the inside pavement width is widened 4 ft. [1.2 m] and there is no longitudinal joint between the Type A1 paved shoulder and mainline pavement. For Type A and A1 shoulders, the edge of the travel lane is delineated by appropriate lane marking. See Figures 6-03.6, 6-03.7, 6-03.9 and 6-03.10.

6-04.2 (3) HEAVY DUTY PAVEMENT RIGID & FLEXIBLE - ALL ADT's. Paved shoulders, Type A and A1, are provided. Type A and A1 shoulders consist of the same material and thickness as the roadway pavement and are an integral part of the pavement structure. Type A shoulders are provided next to the outside traveled way, the pavement width is widened by 2 ft. [0.6 m] and the rigid shoulder is tied to the pavement structure with tie bars. Type A1 shoulders are provided on the median side of dual lane facilities, the inside pavement width is widened 4 ft. [1.2 m] and there is no longitudinal joint between the Type A1 shoulder and mainline pavement. For Type A and A1 shoulders, the edge of the travel lane is delineated by appropriate lane marking. See Figures 6-03.8, 6-03.9 and 6-03.10.

6-04.2 (4) AREAS WHERE EXPANSION IS CONSIDERED IMMINENT. Paved shoulders, Type A, are provided as an integral part of the pavement structure except that they are constructed as a full width lane for potential future lane use.

6-04.2 (5) FLEXIBLE AND RIGID - URBAN, LESS THAN 20,000 ADT. Stabilized or earth shoulders, Type U2, are provided. They consist of a 3 ft. [0.9 m] concrete curb and gutter section and a 5 or 7 ft. [1.5 or 2.1 m] width of stabilized surfacing or earth shoulder. The use of the stabilized or earth shoulder is optional with the district; however, the maximum use of the earth shoulder is encouraged to reduce cost. The selection may be based upon expected usage and aesthetic considerations. The stabilized portion consists of a 2 in. [50 mm] bituminous surface on a 4 in. [100 mm] thickness of Type 5 aggregate. If a shoulder structure other than the above is considered appropriate, a recommendation is made to the Design Division for consideration. The earth shoulder may be sodded or seeded. See Figure 6-04.1.

6-04.2 (6) FLEXIBLE AND RIGID - URBAN, 20,000 ADT OR MORE. Paved shoulders, Type U1, are provided. For the rigid pavement design, the paved shoulder consists of portland cement concrete of the same thickness as the adjacent travel lane, with an integral curb, and on an aggregate base as provided for the traveled way. For the flexible pavement design, the paved shoulder consists of the same structural design as the travel lane, and is provided with a Type S curb, or 3 ft. [0.9 m] concrete curb and gutter section, as applicable. For both rigid and flexible designs, in anticipation of needed expansion, and whenever practical, adequate width will be provided such that the curb can be removed, a new shoulder added with minimum disturbance of the existing pavement and traffic flow and the original shoulder used as a traffic lane. See Figure 6-04.2.

6-04.3 RAMPS. Paved shoulders, Type A, Type A1, or Type A2, are provided. For ramps with integral curbs, the shoulder material and thickness will be specified in the pavement thickness determination.

6-04.4 RESURFACING, RESTORATION AND REHABILITATION PROJECTS. Shoulders for resurfacing projects (non-freeway projects) utilizing 3R design standards are provided as follows. Interstate and freeway projects utilizing 4R design standards have the shoulder design included in the three alternate pavement design strategy. 3R design standards are based on 10-year projected traffic for the following traffic volume ranges:

For 3R resurfacing projects having a 10-year traffic volume of less than 400 ADT, Type E shoulders are provided. Type D shoulders may be recommended by the district operations engineer and justified based on soil properties.

See Figure 6-03.1.

For 3R resurfacing projects having a 10-year traffic volume of 400 to 750 ADT, Type D shoulders are provided. They consist of a 3 in. [75 mm] thickness of Type 1 or Type 2 aggregate. See Figure 6-03.1. The 3 in. [75 mm] aggregate thickness may be increased to 6 in. [150 mm] if recommended by the district operations engineer and justified based on soil properties.

For 3R resurfacing projects having a 10-year traffic volume of 750 to 1700 ADT, Type C stabilized shoulders consisting of a 6 in. [150 mm] thickness of Type 1 or Type 2 aggregate are provided. See Figure 6-03.1. If the 3R design criteria requires the travel lanes to be widened, the existing pavement shall be widened the required 1'-9" or 2'-9" [525 or 825 mm] with full depth (10 in. [250 mm]) base widening. The edge of traveled way shall be striped 9 in. [225 mm] from the edge of widening. See typical section drawings D-70 and D-71 for widening and resurfacing details.

For 3R resurfacing projects having a 10-year traffic volume of 1700 to 3500 ADT, and requiring lane widening to meet 3R design criteria, Type B aggregate stabilized shoulders consisting of an 8 in. [200 mm] thickness of Type 1 or Type 2 are provided. See Figure 6-03.2. If the 3R design criteria requires the travel lanes to be widened, the required widening, either 1 of 2 ft. [0.3 or 0.6 m], is increased by 2 ft. [0.6 m] and delineated at the edge of the travel lane by appropriate lane marking. The aggregate stabilized shoulders may be increased to a thickness equal to the depth of pavement widening (10 in. [250 mm]) plus the resurfacing thickness, if recommended by the district operations engineer and justified based on soil properties.

For 3R resurfacing projects having a 10-year traffic volume over 3500 ADT, and requiring lane widening to meet 3R design criteria, bituminous shoulders are provided. The thickness of the bituminous shoulders will equal the depth of the pavement widening as described in Subsection 6-05.6. For projects that do not require pavement widening to meet 3R design criteria, 5-$^{3}/_{4}$ in. [145 mm] bituminous shoulders, except as otherwise noted below, are provided. The 5-$^{3}/_{4}$ in. [145 mm] bituminous shoulders will consist of extending the 1-$^{3}/_{4}$ in. [45 mm] resurfacing top lift full width across the shoulder on top of a 4 in. [100 mm] bituminous base. If the thickness of the proposed resurfacing is greater than 5-$^{3}/_{4}$ in. [145 mm], then the bituminous shoulder should be the same thickness as the proposed resurfacing. If localized areas warrant a thicker bituminous shoulder, those areas should be designed to handle the expected traffic conditions. Some possible conditions that may warrant a thicker bituminous shoulder are where the shoulder may be used as a future lane, used as a bypass during construction, used as a climbing lane by truck traffic, used as part of a turning radius or an acceleration or deceleration lane at an intersection or a driveway, or used to facilitate expected overload or wide load traffic or known truck parking. When numerous conditions as listed above exist throughout a project, a thicker bituminous shoulder should be considered for the entire project to reduce complexity or to improve constructability. The total shoulder thickness including the resurfacing should never be designed thicker than the total thickness of the roadway pavement. See Figure 6-04.3.

The surface lift should be in accordance with Subsection 6-03.3. No aggregate base material is provided beneath the bituminous shoulder unless it will match the existing pavement and base configuration or it is recommended by the district operations engineer and justified based on soil properties. Prior to placement of any bituminous material on the shoulder, the subgrade must be properly stabilized and compacted. Recommendations for measures to be taken to prepare the shoulder subgrade should be requested from the district operations engineer.

When shoulders (earth, aggregate or bituminous) are to be resurfaced with a bituminous overlay, it is critical that several considerations be made. The intent of the shoulder is to be capable to support a reasonable load, both size and frequency. While deformation or even moderate rutting may be acceptable and easily maintained for an earth or aggregate shoulder, it is not acceptable for a bituminous shoulder. If designed improperly, a bituminous shoulder is difficult to maintain, dangerous to traffic and will be required to be removed and rebuilt under future projects. To prevent this, bituminous shoulders must be constructed properly from the subgrade up and addressed during the design process.

The existing condition of the shoulder is often the best gauge for potential problems. All potholes and wet areas must be removed and replaced with compacted, select material or Type 1 aggregate base. If the shoulder is already bituminous material, all soft material should be removed as deep as necessary and replaced with a similar section, i.e., earth or aggregate followed by a bituminous material to the existing thickness prior to resurfacing. In some

cases, drainage may also need to be improved. Rutted and deformed areas are indicators of not only soft spots, but often identify areas where there is a traffic need to use the shoulders.

Once existing localized distresses are addressed, the designer should specify some sort of compaction effort of the existing shoulder to provide a good, stable base for the bituminous overlay. The following guidelines are offered to assist the district in preparing a job special provision for shoulder subgrade preparation: (1) For stabilized aggregate shoulders with no cut, a self-propelled steel wheel roller weighing not less than 5 tons [4.5 Mg] be used in preparing the subgrade as specified under Sec. 213.2.1 of the standard specification; (2) when cutting into earth or adding on an existing earth surface, require four complete coverages with a tamping-type roller or two complete coverages with a vibratory roller as specified under Sec. 203.3.5 of the standard specifications; or (3) when the shoulder is on a new grade, require compaction with moisture and density control as specified under Sec 203.3 of the standard specifications.

Consideration for using a lower type shoulder stabilization on those routes where future improvements are planned is recommended.

For 3R resurfacing projects having a 10-year traffic volume over 1700 ADT where shoulders have previously been stabilized with bituminous material, the resurfacing is either carried full width over the shoulder or tapered to a zero thickness dependent to some extent upon the existence of guardrail. Good engineering judgment is exercised in the resurfacing of these shoulders. The district operations engineer should make recommendations regarding the adequacy of the existing shoulder structure prior to resurfacing. If the existing shoulder is not adequate for resurfacing, then the shoulder structure will consist of the same material and thickness as described in (4) and (5) above. The accepted AASHTO range in cross slope for bituminous surfaced shoulders is 2 to 6%. See Subsection 4-09.7(2) for guardrail details.

6-04.5 USED-IN-PLACE PAVEMENTS. For pavements to be used-in-place as part of an otherwise improved project and on which shoulders have not been previously stabilized, stabilized shoulders are provided in accordance with the appropriate pavement design categories and design traffic.

6-04.6 SHOULDER RUMBLE STRIPS. Shoulder rumble strips (SRS) should be included on projects with new or resurfaced shoulders that meet the following conditions:

- The design speed is at least 50 mph.
- The outside shoulder has a minimum width of 2 ft. [0.6 m].
- The shoulder does not have a curbed section or the shoulder is not intended to be used as a future travel lane.
- On multiple-lane divided roadways, SRS should be installed on the inside shoulder if it is at least 2 ft. [0.6 m] wide.
- The shoulder is concrete or the final lift of bituminous material is at least 1-3/4 in. [45 mm] thick, and the shoulder has a final paving thickness of at least 3-3/4 in. [95 mm].

Shoulder rumble strips are to be milled into bituminous and portland cement concrete. See Standard Plan 626.00. Shoulder rumble strips are omitted between the radius points for side road approaches, entrances and median crossovers. Shoulder rumble strips should be omitted on bridges and on ramps for diamond, single point, partial cloverleaf and similar types of interchanges, but may be considered on longer ramps for directional or other large interchanges. The length of shoulder rumble strip installation should be estimated and pay items provided.